

3-7-1983

Habitat management for optimum population densities and maximum utilization of snowshoe hares

Rainer H. Brocke

Follow this and additional works at: <http://digitalcommons.esf.edu/awrpr>



Part of the [Animal Sciences Commons](#), [Forest Management Commons](#), [Population Biology Commons](#), and the [Systems Biology Commons](#)

Recommended Citation

Brocke, Rainer H., "Habitat management for optimum population densities and maximum utilization of snowshoe hares" (1983). *Adirondack Wildlife Research Project Reports Funded by the Pittman-Robertson Act*. Paper 15.
<http://digitalcommons.esf.edu/awrpr/15>

This Technical Report is brought to you for free and open access by the Adirondack Ecological Center at Digital Commons @ ESF. It has been accepted for inclusion in Adirondack Wildlife Research Project Reports Funded by the Pittman-Robertson Act by an authorized administrator of Digital Commons @ ESF. For more information, please contact digitalcommons@esf.edu.

HABITAT MANAGEMENT FOR
OPTIMUM POPULATION DENSITIES
AND MAXIMUM UTILIZATION
OF SNOWSHOE HARES

FINAL REPORT 1982

Federal Aid Project W-105-R
New York State Department of
Environmental Conservation
Study X, Jobs 1,2,3,4,5,6,8

Prepared by

Rainer H. Brocke, Ph.D.
Senior Research Associate, Principal
Investigator
Dept. of Environmental and Forest
Biology, S.U.N.Y. College of
Environmental Science and Forestry
Syracuse, New York 13210

This study was supported by the State University of
New York, College of Environmental Science and Forestry,
and by Federal Aid Project W-105-R, New York, the U.S.
Fish and Wildlife Service and New York State Department
of Environmental Conservation cooperating.

Prepared by:

Rainer H. Brocke
Rainer H. Brocke

Senior Research Associate
Title

Principal Investigator:

Rainer H. Brocke
Rainer H. Brocke

Senior Research Associate
Title

Mar. 7, 1983
Date

Approved by:

William F. Porter
Project Leader

Date

Approved by:

Eugene Parks
Supervising Wildlife Biologist

Date

Approved by:

Stuart Free, Chief
Bureau of Wildlife

Date

State: New York
Project No: W-105-R

FINAL JOB COMPLETION REPORT
Job X - 1, 2, 3, 4, 5, 6, 8

STUDY NUMBER AND TITLE: X - Habitat management for optimum population densities and maximum utilization of snowshoe hares.

STUDY OBJECTIVES: To develop habitat management procedures for optimum population densities and maximum utilization of snowshoe hares.

(1) Job No. and Title: X-1 The influence of cover on the behaviour of snowshoe hares.

Job Objective: To determine the influence of cover on the behaviour of snowshoe hares by field observations and experiments.

(2) Job No. and Title: X-2 Habitat management for optimum population densities and maximum utilization of snowshoe hares.

Job Objective: To modify snowshoe hare habitat by selective cutting, clearing and seeding in order to optimize huntability, viewability and population density.

(3) Job No. and Title: X-3 Determination of hare density, observability and huntability on experimental management and control areas.

Job Objective: To determine hare density, observability and huntability on experimental management and control areas.

(4) Job No. and Title: X-4 Analysis and publications of results of habitat management for maximum viewability and huntability and optimum population densities of snowshoe hares.

Job Objective: To analyze and publish results of habitat management for maximum viewability and huntability and optimum population densities of snowshoe hares.

(5) Job No. and Title: X-5 Successional characteristics and hare carrying capacities of selected snowshoe hare habitats in New York State.

Job Objective: To describe key successional characteristics and to estimate hare carrying capacities of selected snowshoe hare habitats in New York State.

(6) Job No. and Title: X-6 Mathematical modeling of snowshoe hare management alternatives which will produce optimum harvests, stable hare populations and economic returns.

Job Objective: To determine by mathematical modeling the snowshoe hare management alternatives which will produce optimum harvests, stable hare populations and economic returns.

(8) Job No. and Title: X-8 Strategic plan for managing the snowshoe hare resource in New York State.

Job Objective: To prepare a strategic plan for managing the snowshoe hare resource in New York State.

OVERVIEW

Snowshoe hare research at Huntington Forest was initiated in 1969 under W-105-R, Study IX (see Job list in Appendix 1). Demography and experimental exploitation constituted the principal focus in the first 2 years. However, it was soon apparent that habitat ecology should be researched in detail leading to the initiation of Study X in 1972. The initial compliment of 4 jobs was expanded to 9 by 1978. One of these jobs (Job X-7) on the establishment of experimental hare management areas in New York State was subsequently dropped and the succeeding jobs were renumbered, producing the present compliment of 8 jobs. Of these jobs, Job X-7 on the development of a cooperative research-demonstration program for hares and small game, remained inactive. The latter decision by the D.E.C. Bureau of Wildlife followed my inspection of two possible western New York sites with Terry Moore, Region 9 Wildlife Manager. Hence, a report on Job X-7 is not included here. In sum, the hare research program grew and developed; while some segments became important, other were deemphasized or discontinued.

Hare management for "observability and huntability" was specifically identified in the titles and descriptions of Jobs X-3 and 4. Early in this research project, it became apparent that the dual objectives of hunting and viewing could not be addressed by a single set of management measures. While both hunting and viewing objectives depend on the availability of dense conifer

cover and an adequate density of snowshoe hares, enhancement of viewability requires special measures because it depends largely on the spring season feeding behaviour of hares and their use of grassy forest openings. Hence, a special report was prepared addressing habitat management for viewing (Final Report, Study X, submitted April, 1980, Appendix 4).

Hare habitat management for hunting objectives was addressed in two previous publications, namely a conference paper (Brocke 1975, Appendix 2) and Final Report for Study IX (submitted March 1977, Appendix 3). The principal objectives of the latter study are demographic in nature. However, it is impossible to separate population management from habitat management. Hence, important habitat management considerations were incorporated in the latter Final Report.

From 1971 through 1981, the snowshoe hare project produced a total of 12 papers, articles, and workshops including 2 technical workshops, 2 papers for sportsmen, 1 popular article and 1 extension article produced in conjunction with the U.S. Soil Conservation Service (see Appendix 1 for complete list). I have personally answered a large number of requests by sportsman's clubs for information on hare management. A number of lectures was given at New York State Conservation Council and other sportsman meetings. Requests for reprints were routinely answered (e.g. 33 copies of the 1975 article were mailed to biologists).

In view of the evolution and changes in emphasis of the snowshoe hare research program and the publications that have been produced to date, an agreement was reached on May 12, 1982 (see Memorandum of Agreement Appendix 1), namely that the Final Report for Study X (this report) shall be comprised of four parts including: (1) Northeast Transactions Paper, Brocke 1975, (2) the Final Report for Study X previously submitted, (3) a new report emphasizing

options for management of snowshoe hares in New York State, and (4) a complete set of reprints of all pertinent popular and technical articles published previously. The key segment of this report is the one on management, essentially the Final Report for Job X-8. Hence, I have used the approach of including items 1, 2 and 4 above in Appendices following the Final Report for Job X-8. Additional appendices to support the Final Report for Job X-8 include the Final Report for Study IX (hare demography and exploitation) as well as information on integrated habitat management for hares and other species (Appendix 5).

Beyond the completion of this report, publication of the results of this study will continue in technical, semi-technical and popular outlets. In particular, a practical bulletin on hare management in New York will be written specifically for agency wildlife biologists, foresters and laymen, including private landowners.

- (1) Job Number and Title: X-1. The influence of cover on the behavior of snowshoe hares.

Job Objective: To determine the influence of cover on the behavior of snowshoe hares by field observations and experiments.

Abstract: The distribution of snowshoe hares in the Adirondack region of New York State corresponds closely with the distribution of conifers. Specifically, hares occur where conifers averaging 3.5 m (11.5 ft.) provide "Base Cover" where hares spend the day. "Travel Cover" consists of conifers about 8.3 m (27.2 ft.) in height. Stands in the latter category provide travel lanes for hares adjacent to Base Cover, but have limited value in the absence of Base Cover. It is essential that conifer cover be continuous. Open areas, large marshes and two-lane highways are barriers to hare movement. In the study area, mean movement distance of 76 hares was 141 m (463 ft.), on the basis of trapping records. It is suggested that the width of conifer blocks should not exceed 200 m. In spring and early summer, hares can be observed in grassy openings. The mean duration of individual hare observations in clearings for mornings and evenings was 13 minutes. Hares in openings stayed on the average 2 m away from the forest edge. Hares apparently venture into sunlit openings to feed on the dense spring growth of annual plants. Stem densities of grasses and annual plants in openings were 3.2 to 17.2 times as great as stem densities in adjacent forest during May. The high level of hare activity in openings in mid-May coincides with mean parturition and conception dates of the first and second litters respectively. Hare activity in openings declines abruptly in May. When approached by an observer walking along a forest trail, snowshoe hares in small openings tend to escape before they are seen. Hares can be observed more readily by persons in autos or on bicycles. In woodland habitat, hares will not travel far from the edge of conifer cover to feed. In lightly cut-over mature deciduous forest, 94.5 percent of all edge-related activity is confined within 30 m from the conifer edge. In heavily cut-over second growth deciduous forest, 89 percent of all edge-related activity is confined within 30 m from the conifer edge. Daily hare activity was experimentally determined for 4 hares held individually in a 10m x 20m pen, partitioned into 8 interconnected compartments and monitored by 48 reed switches fed into a 20 pen Esterlive-Augus strip chart recorder. Hare activity is muted prior to sunset and after sunrise. By far the largest fraction of hare activity is confined to hours of darkness, with a small peak after sunrise and a major peak after sunset.

Background: See attached manuscripts

Procedures: See attached manuscripts

Findings: See attached manuscripts

Analysis: See attached manuscripts

Recommendations: This job has been terminated. The attached manuscripts will serve as the final report for this job.

- (2) Job Number and Title: X-2. Habitat management for optimum population densities and maximum utilization of snowshoe hares.

Job Objective: To modify snowshoe hare habitat by selective cutting, clearing and seeding in order to optimize huntability viewability and population density.

Abstract: A total of 60 experimental clearings and 60 control plots were distributed along a 1.79 mile (2.98 km) stretch of graveled forest road at Huntington Forest. Thirty of the 60 experimental roadside openings were located adjacent to conifer cover; 30 openings were 200 m or more distant from conifer cover. The purpose of this experimental design was to test the hypothesis that hares require avenues of conifer cover to reach feeding areas. Six treatments were applied to the 60 openings (including distance from conifer cover), 10 openings per treatment, as follows: (1) seeding and natural growth in cleared areas; (2) openings lined with dolomitic limestone ($\text{CaCO}_3 \cdot \text{MgCO}_3$) at 2.5 metric tons/ha and fertilized with 10-10-10 fertilizer at 1120 kg/ha; (3) medium red clover and ladino clover applied at the rate of 10 kg/ha and 4.5 kg/ha respectively. Each of these treatments was alternately applied (1) in openings adjacent to conifer cover and (2) in openings located at a distance of 200 m or more from conifer cover, for a total of 6 treatments. Control plots (60) were located adjacent to experimental plots. Preparation of experimental openings was completed one growing season before they were observed for hare use. Large and small trees, branches, brush, debris and leaves were removed prior to raking by hand or by tractor drawn sprintooth harrow. Twenty openings were left bare for natural seeding. Experimental openings and adjacent control plots were identified with painted stakes and numbered signs. All openings were measured and mapped. A network of hunting trails was cut and cleared in the Adjidaumo Hare Study Area with a total length of 3.21 mi (5.35 km), including 2 end trails and 5 cross trails. Numbered trail markers were placed 25 m apart along the entire length of the trail. The area and trails were mapped and maps distributed to hunters. An experimental cut on 10 acres of the 146 acre Adjidaumo Hare Management Area was commercially contracted in 1976. The objectives of this cut were to determine whether existing hare cover could be preserved while overhead hardwood cover was being removed and whether scarification by logging machinery would stimulate conifer reproduction. The forest composition before cutting was measured by 10 prism cruise plots. Post logging composition was estimated from trees marked for cutting. Logging was conducted in summer so that soil disturbance would enhance conifer reproduction.

Background: See attached manuscripts

Procedures: See attached manuscripts

Findings: See attached manuscripts

Analysis: See attached manuscripts

Recommendations: This job has been terminated. The attached manuscripts will serve as the final report for this job.

- (3) Job Number and Title: X-3. Determination of hare density, observability and huntability on experimental management and control areas.

Job Objective: To determine hare density, observability and huntability on experimental management and control areas.

Abstract: Hare density on the Adjidaumo hare study area was determined by near-complete removal of the hare population in late winter of 1978. A total of 42 hares was removed; the remaining snow tracks scattered on the area indicated a pre-removal presence of 50 hares. On the basis of total area (164 acres, 0.25 mi^2 , 0.66 km^2), hare density was estimated at 196.3 hares/mi^2 (75.8 hares/km^2). The estimated hare density was converted to density per pellets counted in standard quadrats. Between May 23 and May 26, 1978, pellets were counted in a total of 100 quadrats over 10 Base Cover locations in the Adjidaumo Hare Study Area. The mean number of pellets counted was 30 ± 5.2 ($\bar{x} \pm \text{SE}$). Thus, the conversion factor for hare density per pellet counted was computed at 6.6 hares/mi^2 (2.52 hares/km^2). These values were used to determine hare densities for Catskill and western New York locations. Observability of hares was determined in (1) two large openings, Opening A located adjacent to a highway and Opening B, a lawn surrounding a family dwelling, (2) in 60 small experimental openings and 60 control plots (see Job X-2), and (3) along grassy shoulders bordering a highway. Morning and evening observation trips for experimental clearings were alternated between 2 observers. The mean duration of individual hare observations for mornings and evenings was 13 minutes. Ninety percent of the time was spent by hares sitting and feeding. The number of hares using openings is directly related to the length of conifer forest edge, namely about 33 m per hare in this study (central Adirondacks). On the basis of pellet counts, hare use of 30 experimental openings and 30 forested plots adjacent to conifer cover was significantly higher than that respectively of 30 openings and forest plots distant (200 m or more) from conifer cover. Hares showed no significant preference for other variously treated experimental openings. The huntability of the Adjidaumo Hare Management Area is reflected by data from 27 experimental hunts involving 124 hunters. The mean number of hunters per hunt was 4.4 for 1976 and 5.3 for 1976-77. The mean number of hours per hunt was 4.7 in 1976 and 4.4 in 1976-77. Slightly less (on the average) than 2 dogs accompanied each party. A total of 1.3 hares were bagged per hunt in 1975-76 and 1.0 in 1976-77. The success rate of the Huntington groups was compared to that of the group of John Paye from northern New York, on the basis of their 10 year diary of hunting data. Paye's group numbering on the average 4.5 (similar to Huntington groups) bagged 5.3 hares per hunt (205 hunts). The mean number of hares bagged per hunter per hunt was

1.3 for Paye's party versus 0.3 (1975-76) and 0.2 (1976-77) for Huntington hunters. Paye's party killed 7 hares in 3 hours when they hunted at Huntington Forest. Observations of hunters showed that most were ineffective, as were their dogs. Hunting success was significantly higher under good weather conditions (i.e. pleasant weather, minimal sinking depth and fresh snow showing tracks) than under poor weather conditions (deep snow, rain, low temperatures). Hunters tended to hunt harder when hare tracks were visible in the snow, and tended to blame their lack of success on "no hares" when tracks were not visible (i.e. after a heavy snowfall ending in the morning). Hunting success on the Adjidaumo area can probably be improved by increasing the number of trails and providing more strategic openings. Ultimately, hunter skill and quality of hare dogs appeared to be the key element to success.

Background:

See attached manuscripts

Procedures:

See attached manuscripts

Findings:

See attached manuscripts

Analysis:

See attached manuscripts

Recommendations:

This job has been terminated. The attached manuscripts will serve as the final report for this job.

- (4) Job. No. and Title: X-4 Analysis and publications of results of habitat management for maximum viewability and huntability and optimum population densities of snowshoe hares.

Job Objective: To analyze and publish results of habitat management for maximum viewability and huntability and optimum population densities of snowshoe hares.

Abstract: Analysis and publication of the results are fulfilled in the Final Reports for Study X, (Observing snowshoe hares in Adirondack forest openings, 67 pp., submitted April 2, 1980), in Brocke 1975 (Preliminary guidelines for managing snowshoe hare habitat in the Adirondacks, Transactions of 32nd Northeast Fish and Wildlife Conference, New Haven, Conn. p. 46-66) in the Final Report for Job X-8 attached hereto, and in 3 technical workshops, 2 papers for sportsmen, 1 popular article and 1 extension article produced in conjunction with the U.S. Soil Conservation Service. A complete list of these products is given in Appendix 1; copies are included in Appendix 5. Additionally, requests for reprints were fulfilled (e.g. 33 for the 1975 article), and a number of lectures were given at meetings of the New York State Conservation Council and sportsman's clubs.

Background: See attached manuscripts

Procedures: See attached manuscripts

Findings: See attached manuscripts

Analysis: See attached manuscripts

Recommendations: This job has been terminated. The attached manuscripts will serve as the Final Report for this job.

Job Number and Title: X-5. Successional characteristics and hare carrying capacities of selected snowshoe hare habitats in New York State.

Job Objective: To describe key successional characteristics and to estimate hare carrying capacities of selected snowshoe hare habitats in New York State.

Abstract: Vegetation quadrats were 5x5 m in size for very dense vegetation and 10x10 m in size for moderate to low vegetation densities. Age of randomly selected trees was determined by increment borer. Tree height, tree diameter at 1 m height (snowline in Adirondacks) and species composition were tallied for all quadrats. The degree of lateral visibility 1 m above ground, a measure of cover density, was determined by reading a 1x1 m density board with 100 squares, alternately colored black and red. Readings were made at 5 m, 10 and 20 m. In the Adirondacks, optimum hare cover consists of conifers, either in large stands as found at high elevations, or as relatively pure stands in lowlands, some disturbed areas or along watercourses. In mixed hardwood-conifer forest, the balsam fir-red spruce component can be increased by selective logging of the overstory. Conifers are self-reproducing in the Adirondacks, given the correct conditions of light and/or disturbance. In the Catskills, balsam fir stands at high elevations are ecologically nearly identical with the equivalent type in the Adirondacks. In the Catskill lowlands, various stand types include an understory of rhododendron and laurel. At the Dietz Farm site, scattered hemlocks in the overstory shaded a dense understory of rhododendron and laurel, with admixtures of yellow birch, red maple, larch and blackberry. On the summit of Ice Caves Mt., a stand of pitch pines included an understory of blueberry, indicating fire succession. Red oak, sassafras and laurels form an admixture with the pitch pine and blueberries. In general, key cover characteristics in the Catskills are inferior to those of optimum cover in the Adirondacks (see abstract, Job X-1). In western New York, Chautauqua County, hares are concentrated in conifer plantations consisting of Norway spruce *Picea abies*, Scotch pine *Pinus sylvestris*, white spruce and jack pine. Some of these stands are about 50 years old, with an open understory invaded by striped maple. One such stand has an admixture yellow birch, beech, white ash, witch hazel, sassafras and serviceberry. Younger stands thinned for Christmas trees have been invaded by blackberry, Arrowwood *Viburnum dentatum*, and various cherry and aspen species. The conifer stands originally planted in open fields have generally not reproduced. A lowland successional forest stand, approximately 20 years old, was studied. This is an open stand (due to poor, wet soil conditions) of red maple, aspens, cherries, some balsam fir and scattered hemlocks, with an understory of arrowwood and wild raisin *Viburnum lentago*. This vegetation type harboring a low hare density is natural, occurring commonly in lowlands. Successional fields overgrown with arrowwood were found to have little value as hare habitat. Estimated hare densities for the Adirondack High Peaks (6 locations) range from 49 to 228 hares/mi² (19 to 86/km²). Elevations of these sites range up to 4800 ft. (1454 m). The cover is principally balsam fir with weak admixtures of paper birch. As these areas are constantly disturbed and the stands semi-permanently stunted, the vegetation is ideal for hares relatively permanently. Hare population density for Adjidaumo mixed forest was 200 hares/mi² (76 hares/km²). Hare densities at 5 locations in the Catskills ranged from 14 to 86 hares/mi² (6 to 33/km²), reflecting inferior habitat quality. Population densities for 8 western New York locations ranged from 1.3 hares/mi² (0.5 hares/km²) to 23 hares/mi² (9 hares/km²). Populations in western New York appear to be weak and declining as a consequence of aging conifer stands and the patchy (or isolated) nature of many stands. As these conifer stands are largely non-reproducing, the prognosis is for continued hare population decline unless planting is implemented on a continuous basis. Naturally reproducing lowland successional

types do not support strong, huntable populations. They merely serve as Travel Cover adjacent to plantations.

Background: See attached manuscripts

Procedures: See attached manuscripts

Findings: See attached manuscripts

Analysis: See attached manuscripts

Recommendations: This job has been terminated. The attached manuscripts will serve as the final report for this job.

- (6) Job Numer and Title: X-6. Mathematical modeling of snowshoe hare management alternatives which will produce optimum harvests, stable hare populations and economic returns.

Job Objective: To determine by mathematical modeling the snowshoe hare management alternatives which will produce optimum harvests, stable hare populations and economic returns.

Abstract: The role of reproduction in replenishing hare populations was modeled. Assuming no immigration or emigration, a population increases itself in one year by a factor of 1.6. This increase is described by the equation $\text{Log } P_t = 0.197t + \text{Log } P_0$, where P_t is the March population at time t and P_0 is the starting pre-breeding population. This reproductive potential represents a doubling of the population every 1.5 years. Data from the studied population suggest that Adirondack populations are generally stable, partially due to emigration into suboptimum habitats. A model of a stable hare population shows that one-half of the annual juvenile production is available for emigration. This "exportable fraction" represents about 80 percent of the pre-breeding population. Most of this fraction may have dissipated by the time hare hunting is at its best in February and March. Thus the late winter population is particularly vulnerable to hunting. Only about 33 percent of the winter population can be removed if reproduction alone is the source of replenishment. The implications of this problem are discussed as they apply to the Catskills, central and western New York. The vulnerability of isolated hare populations to late winter hunting underscores the importance of cover continuity to insure replenishment by immigration. Observability of hares in clearings was modeled. Model 1 is an empirical model testing the hypothesis that the probability of observing 1 or more snowshoe hares in an opening during a given Potential Viewing Period (PVP) is directly related to the number of hares using the opening. The following equation was generated by the model; $\text{Log}_{10} Y = 0.0148 X - 0.117$ ($r = 0.988$) where Y is the number of hares using the opening and X is the percent of time when 1 or more hares are visible in the opening. The model shows that although the percent of time when 1 or more hares are visible increases with each increment of 1 hare, this increase is progressively smaller. These results indirectly support Hypothesis 1. Model 2 tests an additional hypothesis, namely that the probability of observing one or more snowshoe hares in an opening during a given PVP is directly related to the length of time that the opening is being watched. Probability values were computed from the equation for Model 2 for selected observation periods and various numbers of snowshoe hares using the opening. From a management standpoint, the values in Model 2 indicate the following: (1) Openings which are briefly passed along an observation route must be used by a larger number of hares if the observer is to have a reasonable chance of seeing a hare. (2) The probability of seeing a hare in a given opening can be increased by lengthening the observation period. Additional increments of observation time are particularly effective for periods of shorter duration. (3) Openings which are used by a small hare complex must be observed for longer periods of time to assure an acceptable probability of seeing a hare. Hence, small openings are not ideal along observation routes, but are effective surrounding a dwelling whose occupants observe the opening routinely. Implications of these models in management for viewing are discussed.

Background: See attached manuscripts

Procedures: See attached manuscripts

Findings: See attached manuscripts

Analysis: See attached manuscripts

Recommendations: This job has been terminated. The attached manuscripts will serve as the final report for this job.

- (7) Job No. and Title: X-8. Strategic plan for managing the snowshoe hare resource in New York State.

Job Objective: To prepare a strategic plan for managing the snowshoe hare resource in New York State.

Abstract: Between 1926 and 1937, a total of 58,400 hares were stocked in New York State by the Conservation Department. These hares were purchased from other states including Maine and Wisconsin. Snowshoe hares were raised at the Delmar Game Farm and released from the mid 1940s until 1949. The stocking efforts of the 1920s, 1930s and 1940s were generally unsuccessful. The trap and transfer of hares within the state by the Conservation Department commenced in the 1950s and extended to the mid 1970s. In 1959, special holding pens were constructed at DeBar Mountain Wildlife Management Area to consolidate stocks for shipment. Hare range was successfully extended throughout southeastern, central and western New York, although most hare populations were apparently confined to conifer plantations first planted in the 1930s by the C.C.C. Hares are still purchased in Canada and stocked by hunting clubs under D.E.C. permit, although these stocking efforts are biologically unsuccessful. The act of releasing hares appears to give sportsmen a large measure of satisfaction. The mean number of young produced per female per year in the Adirondacks is 6.53, among the lowest reproductive rates recorded anywhere. The mean annual survival rate is 0.46, a comparatively high value. Apparently the low reproductive rate and high survival rate contribute to the stability of Adirondack populations. A population of about 20 hares was experimentally decimated in two alternate years of a 6 year study. Following 86 percent removal of the population by trapping in spring prior to breeding, complete replenishment occurred within 1 year in both instances. Replenishment was primarily by fall immigration via avenues of conifer cover. The population remained relatively stable over the 6 years of study. The annual cycle of population growth and decline was modeled. Population increase is described by the equation $\log P_t = 0.197 t + \log P_0$ where P_t is the March population at time t and P_0 is the starting pre-breeding population. This reproductive potential represents a doubling of the pre-breeding population every 1.5 years. In patchy Adirondack habitats, the net surplus emigrates to sub-optimum cover in the fall and is lost to the hunter (through natural predation). Hence, hare populations are vulnerable to winter hunting. Only about 33 percent of the winter population can be removed if reproduction alone is the source of replenishment. This source of vulnerability emphasizes the importance of cover continuity. Ideal conifer hare cover (Base Cover) averages 3.5 m (11.5 ft.). Travel lanes (Travel Cover) consist of conifers averaging 8.3 m (27.2 ft.) in height and of dense shrub cover, including alders. Hares will venture into clearings to feed in spring adjacent to conifer stands. The mean perpendicular distance of hares from the forest edge is merely 2.0 m. Hares will venture into deciduous forest to feed, although approximately 70 percent of all activity is concentrated within 30 m from the edge. In optimum Base Cover, the mean value for lateral visibility is 1.8 percent and visibility declines to 0 at 20 m. In sub-optimum Travel Cover, the mean value for lateral visibility at 5 m is 14.7 percent. The mean stem densities for Base and Travel Cover respectively are 20,900 and 5,900. In the Catskills, percent lateral visibility at 5 m is 3.3 percent for balsam fir stands on Slide Mountain, 28.4 percent for a lowland hemlock-rhododendron-laurel stand and 10.1 for the pitch pine-blueberry type on Ice Caves Mountain. Stem densities for the latter sites are 16,640 stems/ha, 17,375 stems/ha and 5,682 stems/ha, respectively. Percent lateral visibility at 5m for 3 conifer plantations in Chautauqua County range from 7 percent to 75.4 percent; stem densities range from 25,560 stems/ha to 8,460 stems/ha, respectively. Successional sites (2) in Chautauqua County have values for percent lateral visibility of 52.9 and 38.6; stem densities for these sites were 14,520 and 24,460, respectively. Snowshoe hare population estimates for the Adirondack High Peaks range from 49 to 228/mi² (19 to 86/km²). The estimated density for the Adjidaumo lowland site (central Adirondacks) was 200 hares/mi² (76 hares/km²) and for Base Cover in the Hyslop area, the estimated density is 435 hares/mi² (165/km²). Estimated populations for

5 sites in the Catskills range from 14 to 86 hares/mi² (6 to 33 hares/km²). Population estimates for 8 sites in Chautauqua County range from 0.07 to 23 hares/mi² (0.02 to 9 hares/km²). Catskill populations are moderate to low compared to the Adirondacks. Population densities in western New York are generally very low suggesting that populations are weak and declining. The generally low quality of western New York cover (parameters above), reflect the preponderance of conifer stands that are past the optimum age for hare cover. Lowland mixed successional forest in western New York supports low hare densities but serves to disperse hares and replenish coverts. Viburnum shrub succession on old fields has little value as hare habitat, except as Travel Cover adjacent to conifer plantations. Important habitat management measures for hunting and viewing are: (1) Management for the presence of Base Cover; (2) management for continuous avenues of Base and Travel Cover; (3) conifer stands should not be deep or monolithic; (4) browse should be readily available within a strip 30 m from the edge of conifer cover; (5) hare viewing in spring and summer can be enhanced by providing grassy openings adjacent to hare cover. Other measures for viewing are discussed. A commercial logging operation to remove the hardwood overstory in mixed conifer-hardwood forest was successful in preserving conifer cover. The snowshoe hare is one species that is relatively unresponsive to centralized regulatory management and relatively responsive to habitat management at the local level. The mean age of hunters participating in experimental hunts was 37.7 years (n = 89) in the 1975-76 season and 37.2 (n = 35) in the 1976-77 season. The mean number of hares bagged per hunter per hunt was 0.2 for the Huntington groups. On the basis of a 10 year diary, one rather successful hare hunting party in northern New York averaged 1.3 hares per hunter per hunt. Dogs of many parties were ineffective, as were the hunters. Deep snow, rain or cold depressed hunting success. Hunters tried harder when they could see tracks in the snow. On the basis of statistics compiled in 1966-67, days spent afield by Tug Hill hare hunters was 30 percent of the number of days spent afield by squirrel hunters and 18 percent of the days spent afield by grouse hunters. The merits of current snowshoe hare regulations are discussed. The principal problems in New York snowshoe hare management center on central and western New York. Components of a comprehensive hare management program in New York are: (1) a formal decision by D.E.C. to commit a fraction of conifer stands on appropriate state lands to replanting with conifers (except larch), (2) selection of sites centering on conifer plantations for potential management of snowshoe hares and other wildlife species, (3) establishment of long-term wood harvesting and replanting schedules for the selected sites, (4) clear identification of selected forest complexes as special management areas, (5) involvement of local hunting clubs and conservation clubs in the management activities of selected sites, (6) trap and transfer of snowshoe hares under permit, conducted exclusively by hunt clubs "adopting" special management areas. The current stocking of hares purchased in Canada by clubs can be discontinued, once the new system is in place, (7) an educational program and workshops promoting management of forest wildlife, (8) modifications of current New York State regulations affecting snowshoe hare hunting, including an open season from December 15 to February 28 for all of New York State south of northern New York; with a 2 hare daily bag limit; retention of the current regulations for northern New York; insertion of a paragraph in the hunting regulations, appealing to responsibility of hare hunters to limit hunting effort in small and patchy coverts.

Background: See attached manuscripts

Procedures: See attached manuscripts

Findings: See attached manuscripts

Analysis:

See attached manuscripts

Recommendations:

This job has been terminated. The attached manuscripts will serve as the Final Report for this job.

MANAGEMENT OF THE SNOWSHOE HARE
Lepus americanus RESOURCE IN
NEW YORK STATE - KEY CONSIDERATIONS
AND MANAGEMENT OPTIONS

by

Rainer H. Brocke Ph.D.
Senior Research Associate
Dept. of Environmental and Forest
Biology, S.U.N.Y. College of
Environmental Science and Forestry
Syracuse, New York 13210

FINAL REPORT

Federal Aid Project W-105-R
New York State Department of
Environmental Conservation
Study X, Job 8

1982

This study was supported by the State University of
New York, College of Environmental Science and Forestry,
and by Federal Aid Project W-105-R, New York, the U.S.
Fish and Wildlife Service and New York State Department
of Environmental Conservation cooperating.

Abstract

Between 1926 and 1937, a total of 58,400 hares were stocked in New York State by the Conservation Department. These hares were purchased from other states including Maine and Wisconsin. Snowshoe hares were raised at the Delmar Game Farm and released from the mid 1940s until 1949. The stocking efforts of the 1920s, 1930s and 1940s were generally unsuccessful. The trap and transfer of hares within the state by the Conservation Department commenced in the 1950s and extended to the mid 1970s. In 1959, special holding pens were constructed at DeBar Mountain Wildlife Management Area to consolidate stocks for shipment. Hare range was successfully extended throughout southeastern, central and western New York, although most hare populations were apparently confined to conifer plantations first planted in the 1930s by the C.C.C. Hares are still purchased in Canada and stocked by hunting clubs under D.E.C. permit, although these stocking efforts are biologically unsuccessful. The act of releasing hares appears to give sportsmen a large measure of satisfaction. The mean number of young produced per female per year in the Adirondacks is 6.53, among the lowest reproductive rates recorded anywhere. The mean annual survival rate is 0.46, a comparatively high value. Apparently the low reproductive rate and high survival rate contribute to the stability of Adirondack populations. A population of about 20 hares was experimentally decimated in two alternate years of a 6 year study. Following 86 percent removal of the population by trapping in spring prior to breeding, complete replenishment occurred within 1 year in both instances. Replenishment was primarily by fall immigration via avenues of conifer cover. The population remained relatively stable over the 6 years of study. The annual cycle of population growth and decline was modeled. Population increase is described by the equation $\log P_t = 0.197 t + \log P_0$ where P_t is the March population at time t and P_0 is the starting pre-breeding population. This reproductive potential represents a doubling of the pre-breeding population every 1.5 years. In patchy Adirondack habitats, the net surplus emigrates to sub-optimum cover in the fall and is lost to the hunter (through natural predation). Hence, hare populations are vulnerable to winter hunting. Only about 33 percent of the winter population can be removed if reproduction alone is the source of replenishment. This source of vulnerability emphasizes the importance of cover continuity. Ideal conifer hare cover (Base Cover) averages 3.5 m (11.5 ft.). Travel lanes (Travel Cover) consist of conifers averaging 8.3 m (27.2 ft.) in height and of dense shrub cover, including alders. Hares will venture into clearings to feed in spring adjacent to conifer stands. The mean perpendicular distance of hares from the forest edge is merely 2.0 m. Hares will venture into deciduous forest to feed, although approximately 70 percent of all activity is concentrated within 30 m from the edge. In optimum Base Cover, the mean value for lateral visibility is 1.8 percent and visibility declines to 0 at 20 m. In sub-optimum Travel Cover, the mean value for lateral visibility at 5 m is 14.7 percent. The mean stem densities for Base and Travel Cover respectively are 20,900 and 5,900. In the Catskills, percent lateral visibility at 5 m is 3.3 percent for balsam fir stands on Slide Mountain, 28.4 percent for a lowland hemlock-rhododendron-laurel stand and 10.1 for the pitch pine-blueberry type on Ice Caves Mountain. Stem densities for the latter sites are 16,640 stems/ha, 17,375 stems/ha and 5,682 stems/ha, respectively. Percent lateral visibility at 5m for 3 conifer plantations in Chautauqua County range from 7 percent to 75.4 percent; stem densities range from 25,560 stems/ha to 8,460 stems/ha, respectively. Successional sites (2) in Chautauqua County have values for percent lateral visibility of 52.9 and 38.6; stem densities for these sites were 14,520 and 24,460, respectively. Snowshoe hare population estimates for the Adirondack High Peaks range from 49 to 228/mi² (19 to 86/km²). The estimated density for the Adjidaumo lowland site (central Adirondacks) was 200 hares/mi² (76 hares/km²) and for Base Cover in the Hyslop area, the estimated density is 435 hares/mi² (165/km²). Estimated populations for

5 sites in the Catskills range from 14 to 86 hares/mi² (6 to 33 hares/km²). Population estimates for 8 sites in Chautauqua County range from 0.07 to 23 hares/mi² (0.02 to 9 hares/km²). Catskill populations are moderate to low compared to the Adirondacks. Population densities in western New York are generally very low suggesting that populations are weak and declining. The generally low quality of western New York cover (parameters above), reflect the preponderance of conifer stands that are past the optimum age for hare cover. Lowland mixed successional forest in western New York supports low hare densities but serves to disperse hares and replenish coverts. *Viburnum* shrub succession on old fields has little value as hare habitat, except as Travel Cover adjacent to conifer plantations. Important habitat management measures for hunting and viewing are: (1) Management for the presence of Base Cover; (2) management for continuous avenues of Base and Travel Cover; (3) conifer stands should not be deep or monolithic; (4) browse should be readily available within a strip 30 m from the edge of conifer cover; (5) hare viewing in spring and summer can be enhanced by providing grassy openings adjacent to hare cover. Other measures for viewing are discussed. A commercial logging operation to remove the hardwood overstory in mixed conifer-hardwood forest was successful in preserving conifer cover. The snowshoe hare is one species that is relatively unresponsive to centralized regulatory management and relatively responsive to habitat management at the local level. The mean age of hunters participating in experimental hunts was 37.7 years (n = 89) in the 1975-76 season and 37.2 (n = 35) in the 1976-77 season. The mean number of hares bagged per hunter per hunt was 0.2 for the Huntington groups. On the basis of a 10 year diary, one rather successful hare hunting party in northern New York averaged 1.3 hares per hunter per hunt. Dogs of many parties were ineffective, as were the hunters. Deep snow, rain or cold depressed hunting success. Hunters tried harder when they could see tracks in the snow. On the basis of statistics compiled in 1966-67, days spent afield by Tug Hill hare hunters was 30 percent of the number of days spent afield by squirrel hunters and 18 percent of the days spent afield by grouse hunters. The merits of current snowshoe hare regulations are discussed. The principal problems in New York snowshoe hare management center on central and western New York. Components of a comprehensive hare management program in New York are: (1) a formal decision by D.E.C. to commit a fraction of conifer stands on appropriate state lands to replanting with conifers (except larch), (2) selection of sites centering on conifer plantations for potential management of snowshoe hares and other wildlife species, (3) establishment of long-term wood harvesting and replanting schedules for the selected sites, (4) clear identification of selected forest complexes as special management areas, (5) involvement of local hunting clubs and conservation clubs in the management activities of selected sites, (6) trap and transfer of snowshoe hares under permit, conducted exclusively by hunt clubs "adopting" special management areas. The current stocking of hares purchased in Canada by clubs can be discontinued, once the new system is in place, (7) an educational program and workshops promoting management of forest wildlife, (8) modifications of current New York State regulations affecting snowshoe hare hunting, including an open season from December 15 to February 28 for all of New York State south of northern New York; with a 2 hare daily bag limit; retention of the current regulations for northern New York; insertion of a paragraph in the hunting regulations, appealing to responsibility of hare hunters to limit hunting effort in small and patchy coverts.

CONTENTS

ABSTRACT	18
INTRODUCTION	21
PROCEDURES	23
RESULTS AND DISCUSSION	25
SECTION 1. STOCKING IN NEW YORK - A HISTORICAL PERSPECTIVE.	25
SECTION 2. DEMOGRAPHY AND EXPLOITATION.	39
SECTION 3. HABITAT ECOLOGY AND MANAGEMENT.	43
Habitat Ecology.	43
Habitat Characteristics in New York State.	47
Population Densities in New York State.	61
Habitat Management for Hunting and Viewing.	70
SECTION 4. HARE HUNTING AS A SPORT.	76
SECTION 5. MANAGEMENT OPTIONS.	87
LITERATURE CITED	96
APPENDICES	99

INTRODUCTION

The purpose of this report is to consider key factors in the management of snowshoe hares in New York State and to present potential management options. Towards that end, I have avoided considering peripheral detail on hare ecology. Background information is presented in the first portion of the report. The Appendices include three technical papers which function as an integral part of this report, although the paper on hare demography (Appendix 3, Final Report for Study IX) is not formally identified as a part of this report (Study X). These three papers (Appendices 2, 3 and 4) should be referred to for detailed information summarized in the Background section. Management options are considered in the final portion.

Over the years, a number of professionals, students and friends have contributed directly or indirectly to the implementation of this research project. I thank J. Dell and C.W. Severinghaus of the New York State Department of Environmental Conservation (NYSDEC) and D.F. Behrend, State University of New York, College of Environmental Science and Forestry (C.E.S.F) for their contributions in the initial development of the study. Assistance in coordinating workshop presentations was contributed by R.E. Chambers, R.W. Sage and W. Tierson, C.E.S.F. I am grateful to T. Moore, Region 9 Wildlife Manager for leading 2 field trips in western New York. A field trip to the southern Catskills was conducted by Q. Van Nortwick, Region 4 Wildlife Manager. W.C. Tierson and W.F. Porter, former and current Directors of Huntington Forest respectively, provided assistance in project administration. Discussion of the study during project reviews with D. Schierbaum, B. Tullar, G.F. Mattfeld, G. Parsons and other D.E.C. biologists were most helpful. R.W. Sage and R. Masters of Huntington Forest, were indispensable in coordinating

technical help. I am very grateful to the many individuals who provided technical assistance; most are identified in the individual papers appended to this report. I would also like to thank G. Warburton, D. Kinney, and B. Chipman, students at ESF for their technical assistance. I am most grateful to J. Paye for his 10 year diary on hare hunting in northern New York.

PROCEDURES

Technical procedures for habitat measurement are given in Appendices 2 and 4. Techniques for population and reproductive measurements, snow tracking and other demographic parameters are given in Appendix 3. Hare feeding behavior adjacent to conifer cover was determined by pellet counts, vegetation measurements and browse tallies along 90 m transects using 200 quadrats, 10x10 m in size and 200 quadrats 2x2 m in size.

A commercial logging operation was implemented in the Adjidaumo Hare Study Area to determine whether the hardwood component could be selectively logged while leaving strips and patches of conifer undamaged. A 26 percent basal area cut was completed on 10 acres of the 146 acre study area.

Twenty-seven experimental hare hunts were conducted during the winters of 1976 and 1977 at Huntington Forest. All hunters were checked in at station headquarters before each hunt; each party was accompanied by an observer. Following the hunt, hunters filled out questionnaires. A total of 126 hunters participated.

Snowshoe hare population estimates for various New York locations were made on the basis of hare pellet counts in 1m x 1m quadrats, spaced 1 m apart along a transect through each cover site. Pellet counts were made in late spring or early summer if possible; for pellet counts made in summer, winter pellets were separated from summer pellets. Only winter pellets were tallied in order to represent winter populations.

Pellet counts were converted to population estimates on the basis of a near removal of hares by box trapping in late winter in the Adjidaumo Hare Study Area. Hare pellets were subsequently sampled. Vegetation and hare population assessments were made variously in the Adirondack High Peaks region, central Adirondack lowlands, the Catskill region and western New York (Chautauqua County).

A peripheral Adirondack location at Malone was originally slated for sampling. However, inspection of the area showed that central Adirondack lowland sites were representative.

Perspectives on DEC Regional snowshoe hare management problems were obtained during field trips with DEC wildlife managers in the Catskills and Western New York, and through workshops conducted for DEC wildlife managers and foresters in 1977, 1978 and 1980.

RESULTS AND DISCUSSION

SECTION 1. STOCKING IN NEW YORK - A HISTORICAL PERSPECTIVE

Snowshoe hares were stocked by the New York State Conservation Department at least as early as the mid 1920s. Stocking efforts since that time were of various types, reflecting the practice of the day, including (1) the liberation of hares purchased out-of-state, (2) the production and stocking of game farm hares, and (3) the trapping and transfer of snowshoe hares within New York State. Hare stocking efforts involving the Conservation Department began on a large scale. Between 1926 and 1933, 25,700 hares were released (Bump 1941). Again, between 1933 and 1937, a total of 32,700 was stocked (Op. Cit.). These hares were purchased from other states, including Maine and Wisconsin.

The course of Conservation Department stocking efforts in New York is reflected in the history of one area, namely the Connecticut Hill Wildlife Management Area (11,610 acres) in Schuyler and Tompkins Counties (Richmond and Chein, 1976). In 1931, 1934 and 1936, a total of 327 hares were released in 3 stockings respectively (Op. Cit.). In 1941, 27 hares wild-trapped in New Brunswick and Ontario were released. Delmar game farm-reared hares (166) were liberated on the area in 1945, followed by releases in 1952 and 1953 of 43 and 15 hares respectively, wild-trapped in the Adirondacks. Richmond and Clein (1976, p.8) state: "Apparently, the stocking prior to 1941 was in vain because Dell (1951) reported that hares were not present at the time game farm-reared animals were released in 1945. Since subsequent releases of wild caught hares were made in the early 1950's, it is not known whether the hares surviving at the time of the survey (1972, authors note) had derived from farm-reared or wild-caught stock, or both". It is interesting to note that the first conifer plantings listed by Richmond and Chein (1976) date back to 1936.

These plantings would have been too young to serve the game farm stock released in 1945. However, these stands would have been 16 years old in 1952 when the 43 wild-trapped Adirondack hares were released, an ideal size to serve as hare habitat.

Raising snowshoe hares on the Delmar Game Farm commenced in the mid-1940s and releases were apparently conducted until 1949 (DEC file). The success of the game farm hare stocking effort is reflected in the two following reports (DEC file). Between 1944 and 1949, a total of 702 tagged hares were released during the summer and winter months in Otsego, Greene, Albany, Rensselaer and Sullivan Counties. Reporting on this stocking effort, a Department Wildlife Manager states: "In no instances were populations of varying hares proven to have been established as a result of game farm hares. Positive evidence of survival (out of 702 tagged hares) was obtained in regard to only 5 individuals". Commenting on liberations of game farm hares in the Albany area, the latter individual (1946) states: "Only one survivor was located as a result of liberations of 649 hares made on 7 areas on which no native hares existed. No evidence of production of young was found as a result of liberation of game farm stock on areas where hares were not present".

By contrast, the potential success of hare trap and transfer stocking efforts was soon apparent, as suggested by a Departmental memo in 1948 (DEC file). Commenting on the release of 24 wild-caught hares in the Bear Swamp area near Albany, a wildlife manager states: "Although only a few wild-caught hares were released in the study area, excellent results have been recorded. About 15% effective survival has been recorded, even though a large portion of the habitat has not been intensively surveyed (for snow tracks)". Apparently, this colony subsequently died out, according to a later memo of J. Dell (1954, DEC file). Dell's crew found no hare tracks in the snow while

searching the Bear Swamp area during the winter of 1954, even though wild-caught Adirondack hares had been liberated there during the two previous winters.

The Department's hare trap and transfer operations intensified in 1956 and continued throughout the 1960s (DEC file). The last year of recorded stocking was 1972, although local efforts probably continued beyond that year. This trap and transfer effort led by J. Dell (Varying Hare and Cottontail Investigations, Federal Aid Project) was biologically successful and accounts for probably most if not all snowshoe hare population expansion since settlement of the state (Fig. 1). The success of this operation was predicated on the establishment of conifer plantations on abandoned farmlands throughout New York State, by the CCC program and later by wildlife habitat restoration under Federal Aid Project W-48-D (Chase 1961). The Departmental stocking program included the following types of transfers:

- (1) Direct trap and transfer from the Adirondack region (DEC Region 5 and 6¹) to southerly stocking areas (DEC Regions 3, 4, 7, 8, and 9, see Fig. 2).
- (2) Direct trap and transfer within the Adirondack region (DEC Region 5 and 6).
- (3) Direct trap and transfer from the Adirondack region (Regions 5 and 6) to more southerly stocking areas, with an intermediate collecting point (holding pens) at DeBar Mountain Game Management Area in Franklin County.

¹

The hare stocking was originally conducted by the New York State Conservation Department subsequently renamed Department of Environmental Conservation (DEC). After reorganization, the Regions were renumbered; the latter (current) Regional designations are given here.

Fig. 1. New York range occupied by snowshoe hares in 1946, and again in 1976 following the Conservation Department's trap and transfer program, after a map of hare range estimated by J. Dell.

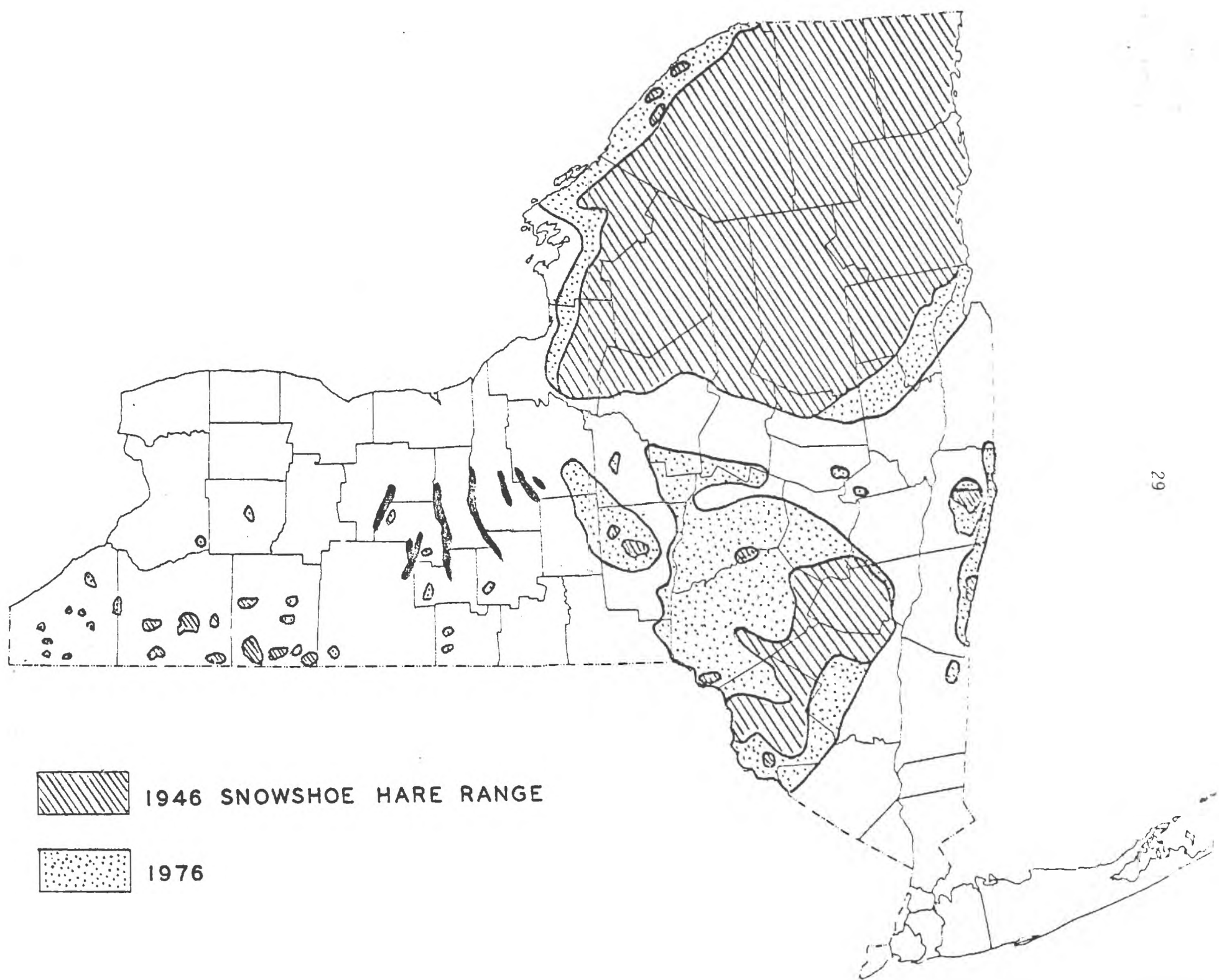
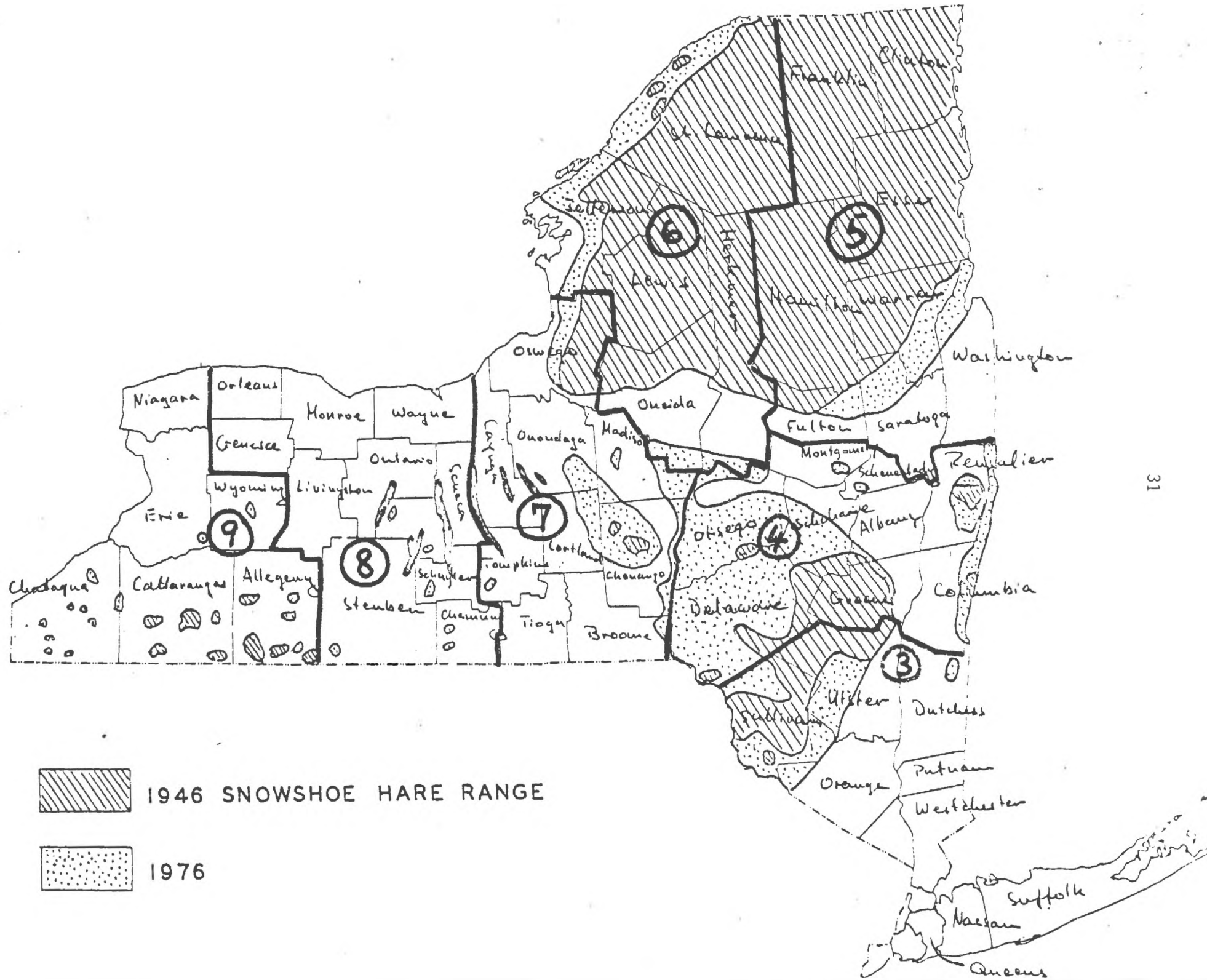


Fig. 2. New York snowshoe hare range as estimated by J. Dell, showing current DEC regional subdivisions and counties.



- (4) Trap and transfer within more southerly areas (Regions 3, 4, 7, 8 and 9), presumably involving some hare stocks established from previous transfer of Adirondack hares.

Judging from the relative numbers of reports and memos (DEC file), most of the trap and transfer "transactions" were of type 1, namely direct trap and transfer from the Adirondack region to points south. The mean number of hares per shipment to individual areas was 43.1 animals (limited sample $n = 22$), ranging from 6 to 152. Most recorded shipments (DEC file) originated in Jefferson County, the Tug Hill area, including Camp Drum. Hares were released on public lands, particularly state reforestation areas in Region 7, especially Madison County, and Regions 4, 8 and 9, especially Cattaraugus County. One 1962 shipment from Jefferson County contained 217 hares released on various sites in 4 counties, Regions 4, 7, 8 and 9. Transfers within the Adirondack region (type 2) were mainly within Jefferson County.

Accumulation of hare stocks prior to shipment necessitated temporary confinement of hares. Animals held in shipping crates for more than 3 days lost vigor and those held beyond 5 days were subject to mortality (Chase 1961). Special holding pens were constructed in 1959 to overcome this problem, at DeBar Mountain Wildlife Management Area, Franklin County. Hares were held at this site, prior to shipment south (type 3 stocking). This pen was operational as late as 1970 when 75 hares were shipped from the site to western New York.

Trap and transfer of hares within the DEC Regions (type 4) was quite fluid and apparently few records were kept as reflected in the following memo of a Department Regional Supervisor (1959, DEC file): "The trapping-transfer program of varying hare is now handled rather informally and I wonder if

adequate provisions are made for season closures if necessary in the areas being stocked". The following two examples of type 4 stocking are illustrative: one group of 32 hares trapped in Madison County (1956) was released in the Tiophnioga Game Management Area (3600 acres) in the same county. Another shipment of 112 hares captured in Madison County was distributed over 6 sites in the same county in groups ranging from 8 to 82 hares per release.

The importance of cover assessment in the trap and transfer program is indicated by Dell (1954) as follows: "Attempts to re-establish the varying hare in certain sections of New York State where they do not now exist should be limited to that type habitat which has been proven suitable for their existence, namely extensive areas of upland coniferous reforestation. Areas offering less than a combined total of one square mile of such habitat are not recommended for stocking since it is extremely doubtful that huntable populations can be sustained through natural reproduction". Again, answering a letter of inquiry Dell (1958) states: "We don't advocate stocking in cover already occupied by the species, even in small numbers, since tests have shown that the fault lies with the habitat and not the lack of breeders". Potential varying hare liberation areas (1946) are shown in Fig. 3. However, only 14 areas were initially chosen for stocking, according to a later memo (Dell 1952, DEC file). Actual stockings in the late phases of the program were probably implemented on a significant number of additional areas as a matter of local (Regional) initiative.

Stocking efforts by sportsmen are limited to releases by Departmental permit only. Hare stocks purchased out-of-state constitute all such releases. In 1966, at least 6 hunting clubs in Sullivan County alone released hares on their lands in lots ranging from 25 to 100 (Dell memo, 1966). Judging from a limited sample of stocking permits ($n = 7$, DEC file), a common source of

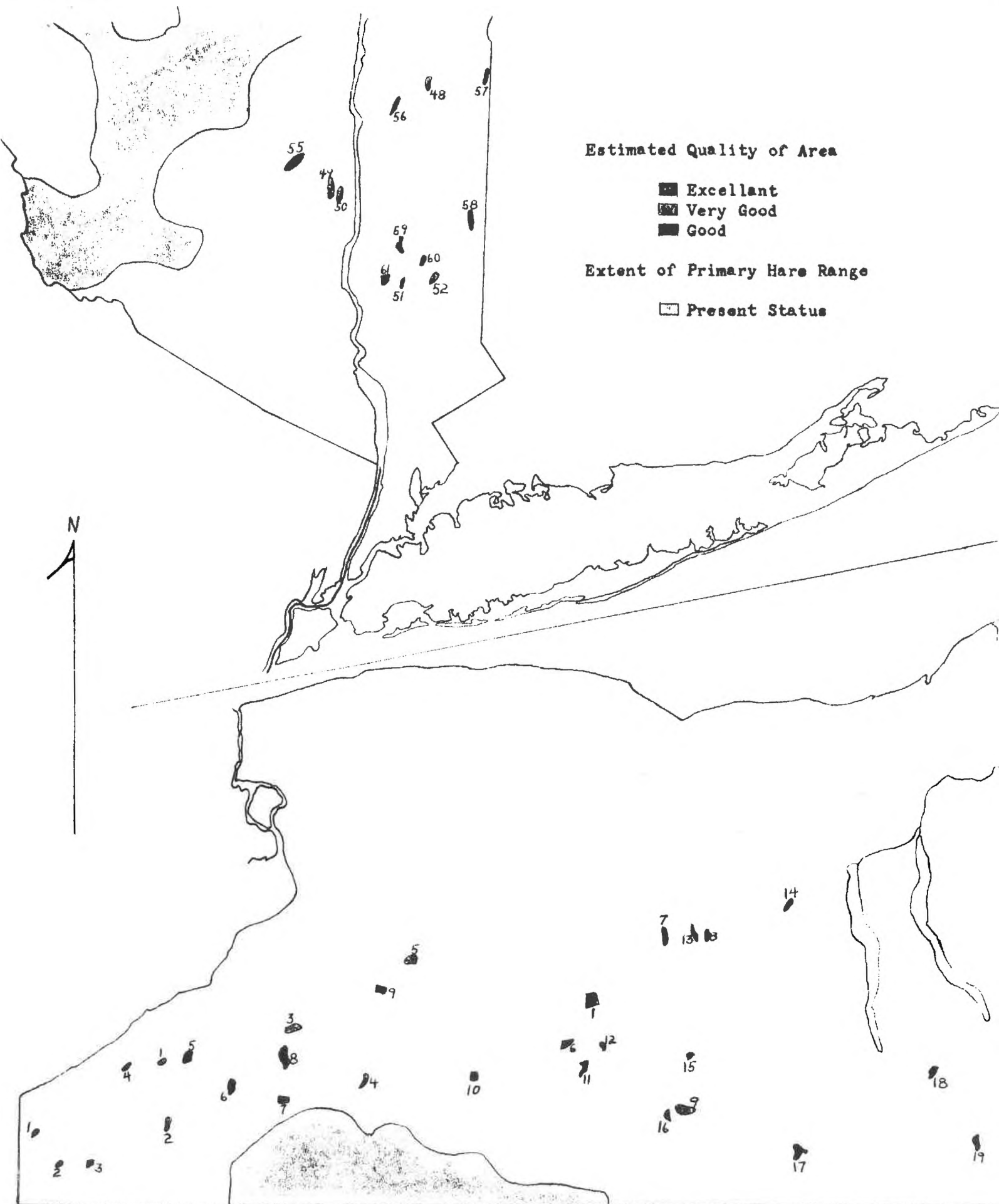
Fig. 3. Potential snowshoe hare liberation sites
in New York State (1946-47, unpubl. map, DEC file).

Estimated Quality of Area

- Excellant
- Very Good
- Good

Extent of Primary Hare Range

- Present Status





purchased hare stocks is Castalia, New Brunswick, Canada. One shipment originated in Vermont and another in Maine. Permits to Adirondack region clubs are common. It is probable that most of these stockings are in poor habitat. If the habitat had been adequate, hares would have been present.

As noted previously, stocking of imported hares is of little or no biological value. Survival of such released hares is low, according to studies in Massachussetts (Boyle 1955, Fitzpatrick 1957, Behrend 1960, Schultz 1978). Of 75 New Brunswick hares stocked in western Massachussetts during the winters of 1975 and 1976, only 17% survived over 16 days in the field (Schultz 1978). A total of 87% of these hares was found dead by Schultz, 74% dying of unknown causes. Additionally, little or nothing is currently known about the potential hazards of introducing diseases and parasites in such stockings.

Speaking at a meeting of the Fulton County Sportsmen, Johnstown, New York, Dell (1976) indicated the biological and economic liabilities of stocking hares. This group had regularly purchased and released Canadian hares on lands of the Pine Tree Rifle Club. At the same meeting, I discussed the importance of habitat management for hares, including demonstrations in the field. To my knowledge, little or no habitat improvement was subsequently conducted by the club, although stocking continued. This is a rather typical attitude of sportsman's clubs. Judging from my contacts with this and other groups, it seems to me that the perceived benefits of stocking (i.e. producing hares to shoot or reproduce) may be only a small part of the overall benefit. Indeed, it is my impression that a substantial value of stocking for sportsmen may be simply the physical act of releasing hares, including handling them and watching them escape into cover. Often, such releases draw crowds of sportsmen and become minor celebrations. Additionally, releases give sportsmen a tangible feeling of doing something constructive for game management and the future of

of hunting. In short, stocking hares is commonly perceived as fun.

On the other hand, habitat management is frequently viewed as hard work. Thinning conifer stands, removing competing hardwood stems or planting seedlings may not be pleasant and the benefits of planting may lie beyond the lifetime of the planter. Additionally, it takes a degree of organization and planning to provide land on which habitat improvement can be done. For the future, an important challenge in hare management will be to harness the local initiative of sportsmen in habitat management. This may be accomplished by integrating habitat management with the "fun" aspects of management, namely censusing hares and stocking by trap and transfer. Such integrated programs (discussed under Management Options) supervised by the DEC can be implemented on public and private lands. Hare management can be locally integrated with ruffed grouse, cottontail rabbit and turkey management.

Looking back, it is easy to fault the hare stocking efforts of the 1920s and 1930s as well as the game farm stocking program of the 1940s. However, while these programs were not biologically successful, they did contribute "psychological success" in terms of sportsman's perceptions. They provided public relations benefits and probably fostered support of sportsmen for the Department in general.

SECTION 2. DEMOGRAPHY AND EXPLOITATION.

In this section, key demographic parameters are emphasized as they apply to New York State. Data on estimated hare populations for various New York habitats are presented in the next section (Section 3 on habitat management). The summarizing discussion in this section is based largely on the Final Report for Study IX (Brocke 1977, Mechanics of replenishment of a heavily hunted hare population, copy in Appendix 3). The reader is encouraged to seek detail in the appended paper.

Reproduction of Adirondack hares is among the lowest recorded anywhere, with a mean number of young produced per female per year of 6.53 (Brocke 1977, Appn.3, p. 8). This value is similar to those reported for Michigan and Minnesota, and lower than those reported for Maine, Newfoundland, Colorado, and Utah (Appn.3, p. 8). Contrasting strongly with the New York mean value are the reproductive rates recorded for Rochester, Alberta (Keith and Windberg 1978). The lowest mean annual reproductive rate per female was 7.5 young recorded during a population decline, while the mean rate was as high as 17.8 young per female recorded during a period of population increase (Op. Cit.). Alberta hares produce up to 4 litters, versus a maximum of 3 for New York. The mean annual survival rate for Adirondack hares is 0.46 (or 0.45 for adults, spring to spring, Appen. 3, p.12), a value similar to that recorded for the Rocky Mountains, but higher than for most other areas (Appen. 3, p. 13), including Alberta (Keith and Windberg 1978). The latter authors recorded a 9 year mean annual survival rate of 0.28 for adult hares in Alberta where pronounced cyclic fluctuations occur. On the basis of the lower reproductive rates and survival rates observed for Adirondack hares, one would expect that northern New York hare populations are generally stable. This appears to be the case, although greater numbers of hares are observed locally in

some years. These "highs" may be the consequence of enhanced juvenile survival during dry spring seasons. In any case, it is probably safe to infer that northern New York hare populations are not cyclic. Data for hare reproduction and survival in the Catskills, central and western New York are currently not available.

Replenishment of an experimentally exploited hare population was investigated at the Hyslop Experimental Hare Study Area in the central Adirondacks (Appen. 3, p. 20). A hare population with a pre-breeding spring mean of 20.2 individuals was studied from 1970 through 1975. This population was experimentally decimated in late winter of 1971 and 1973, with no treatment in the years 1970, 1972, 1974 and 1975. Hares were captured by trapping and live snaring; 86% of the population was removed; the few remaining hares could be individually identified (Appen. 3, p. 22). Complete replenishment occurred in one year following both instances of decimation. It is interesting to note that for the two years directly following decimation, the winter activity of predators (red fox, gray fox, coyote, bobcat and fisher) ceased almost completely, judging from snow track surveys (Appen. 3, p. 26). Apparently, the near complete removal of hares in 1971 and 1973 left little stimulus for predators in the study area during spring of those years when reproduction made their needs most critical. It is noteworthy that this apparently learned response carried into the winter of the following year when the hare population had returned to the normal level.

A striking feature of this manipulated hare population was its stability through the 6 years of study. For 3 of the 6 years, an unmanipulated control population on an adjacent area was also monitored (Appen. 3, p. 20). It too remained relatively stable, judging from box trapping success indices. Initial replenishment of the exploited population appeared to be the result of juvenile

immigration in the fall and winter months along avenues of continuous cover, judging from snow tracking (Appen. 3, p. 28). The role of reproduction in replenishing the population was modelled (Appen. 3, p. 29). Population increase from year to year is described by the equation:

$$\text{Log } P_t = 0.197t + \text{Log } P_0$$

where P_t is the March population at time t and P_0 is the starting pre-breeding population. This reproductive potential represents a doubling of the pre-breeding population every 1.5 years. Assuming that no net immigration or emigration were to occur, a population of 20 animals would increase in 1 year by 11 individuals. Modelling the annual cycle in a stable population of 20 animals (i.e. a pre-breeding population of 20 hares), the population would be at its lowest point in March at 20 animals, it would reach 61 by July (litter 3), lose 15 hares to emigration from its October population of 43 and decline to 20 animals again by March. The scenario represented by this model is as follows: the population reproduces to its highest point in July, but by November the excess hares have emigrated from prime hare cover into vacant primary cover or marginal cover where they are subject to greater predatory losses. By December, the population is 25, barely above the pre-breeding population level (for details on this and other models, see p. 29-42 in Appen. 3).

The models clearly illustrate an important biological weakness of winter hare hunting in the patchy hare cover which is locally common in New York State, namely that such winter hunting exploits the resident breeders after the surplus has dissipated in the fall. This surplus is lost to the hunter. The effect can be illustrated using the model given above. If this hare population were hunted in October, the exportable surplus of 15 hares (or at least some of it) would be exploited still leaving a pre-breeding population

of 20 animals. On the other hand, if 5 hares are removed respectively in January, February and March, only 6 hares would remain in late March and it would require 3 years for the population to reach 20 (pre-breeding level) again. The data in Tables 15 and 16 (Appen. 3, p. 35) indicate that only about 33% of the late winter population can be safely removed, if reproduction alone is the source of replenishment. It should be noted that these models are based on survival rates in a stable population. The actual survival rates may be somewhat higher in an exploited population. If they are, then the effect predicted by the models may not be as pronounced. In any case, the predicted effect is valid, in my opinion, and should be considered as operable in making management decisions.

The vulnerability of isolated hare populations illustrated by these models is not an important consideration in the Adirondack region where strips of coniferous cover along streams and lake edges, and conifer blocks at higher elevations form a continuous network of travel lanes. In such an environment it is virtually impossible to over-exploit a hare population, as the experimental exploitation at Hyslop has shown. However, in the central and western New York region where isolated plantations and coverts are common, especially where highways and cultivation create barriers to hare movement, there is the real danger of local over-harvest.

SECTION 3. HABITAT ECOLOGY AND MANAGEMENT

Habitat Ecology

A central characteristic of good snowshoe hare habitat is the presence of young conifer stands. Essential characteristics are summarized by Brocke, 1975 (see Appendix 2), as follows: "The distribution of snowshoe hares in the Adirondack region of New York State corresponds closely with the distribution of conifers. Specifically, hares occur where conifers averaging 3.5 m (11.5 ft.) provide "base cover" where hares spend the day. "Travel cover" consists of conifers about 8.3 m (27.2 ft.) in height. Stands in the latter category provide travel lanes for hares adjacent to base cover, but have no value for hares in the absence of base cover. It is essential that conifer cover be continuous. Open areas, large marshes and two lane highways are barriers to hare movement". Subsequent studies have supported the importance of the conifer component in snowshoe hare habitat in widely different areas including Nova Scotia (Orr and Dodds 1982), Alaska (Wolff 1980) and Utah (Wolfe et al. 1982).

The close association of hares with conifer cover is shown by the data in Tables 1, 2 and 3. Hares will not travel far from conifer cover to feed. Most of the feeding is concentrated at or near the edge, in both lightly cut-over second growth deciduous forest (Table 2). Approximately 70% of all activity is concentrated within 30 m from the edge. The close association of hares with conifer cover in winter, as illustrated to a large extent by the data above (primarily counts of winter pellets), is not confined to this section alone. In summer, hares also tend to remain close to conifer cover as observed directly for hares in clearings (Table 4, Appendix 4). Indeed, the mean perpendicular distance of hares from the forest edge is merely 2.0 m (Table 4). Additional details on the importance of conifer cover are given

Table 1. Feeding activity of hares as indicated by pellet counts at various distances up to 70m from the edge of conifer cover in lightly cut-over mature deciduous forest (see text).

Quadrat location relative to conifer edge (m)	All Samples		Samples beyond Edge	
	$\bar{X} \pm S$ n=10 per sample	Percent of sample total (51.4)	\bar{X}	Percent of sample total (13.4)
-10	16.3 \pm 9.0	31.7	-	-
0 Edge	21.7 \pm 22.0	42.2	-	-
+10	3.5 \pm 3.4	6.8	3.5	26.1
+20	4.2 \pm 3.1	8.2	4.2	31.3
+30	2.9 \pm 4.7	5.6	2.9	21.6
+40	1.7 \pm 3.1	3.3	1.7	12.7
+50	0.4 \pm 0.7	0.8	0.4	3.0
+60	0.6 \pm 1.0	1.1	0.6	4.5
+70	0.1 \pm 0.3	0.2	0.1	0.7
Total	51.4	99.9	13.4	99.9

Table 2. Feeding activity of hares as indicated by pellet counts, related to the edge of conifer cover in heavily cut-over second growth deciduous forest (see text).

Quadrat location relative to conifer edge (m)	All Samples		Samples beyond Edge	
	$\bar{X} \pm S$ n=10 per sample	Percent of sample total (234.5)	\bar{X}	Percent of sample total (45.2)
-10	112.6 \pm 107.0	48.0	-	-
0 Edge	76.7 \pm 87.7	32.7	-	-
+10	11.7 \pm 14.1	5.0	11.7	25.9
+20	8.6 \pm 9.3	3.7	8.6	19.0
+30	7.6 \pm 5.7	3.2	7.6	16.8
+40	4.4 \pm 4.1	1.9	4.4	9.7
+50	4.4 \pm 3.0	1.9	4.4	9.7
+60	2.7 \pm 3.1	1.1	2.7	6.0
+70	5.8 \pm 8.5	2.4	5.8	12.8
Total	234.5	99.9	45.2	99.9

Table 3. Feeding activity of hares as indicated by pellet counts at various distances up to 70m from the edge of conifer cover. Data for lightly cut-over and heavily cut-over deciduous forest combined (from Tables 1 and 2).

Quadrat location relative to conifer edge (m)	Combined percentage	Percent activity for both forest types	Cumulative percent activity
10	52	26	26
20	50	25	51
30	39	19.5	70.5
40	23	11.5	82.0
50	13	6.5	88.5
60	10	5.0	93.5
70	13	6.5	100.0
	200	100	-

in Appendices 3 and 4; the structure of hare habitat is discussed in Appendix 2.

Habitat Characteristics in New York State

Characteristics of Adirondack habitat are given in Appendix 2. The most important component is Base Cover, consisting of conifers of various species, ranging in height between 2.6 and 4.5 m. As far as hares are concerned, escape from predation is an important value of this cover as the species is preyed upon by a large variety of predators (see Brocke 1977, Appen. 3, Powell 1978, Adamcik et al. 1979). Lateral visibility at ground (or snow level) appears to be an important measure of cover quality, a function of hare-predator relationships. In optimum Adirondack Base Cover, the mean value for lateral visibility is 1.8% (range 0.4 - 2.8%) at 5m. Visibility declines to 0 at 20m (Table 1, Appen. 2). In sub-optimum Adirondack Travel Cover, the mean value for lateral visibility at 5m is 14.7% (range 8.8-22%). Visibility declines to 2.6% at 20 m. The mean height for Adirondack Base Cover is 3.5 m; it is 7.3 m for travel cover. A density of about 8000 stems/ha can be used as a convenient dividing line between Base Cover and Travel Cover. The mean stem density for Base Cover is 20,900; it is 5,900 for Travel Cover (Tables 1 and 2, Appen. 3). These data are useful as a basis for comparing and assessing hare habitat quality in the Catskills and western New York, and in explaining regional differences in hare population levels.

Representative locations in the Catskills and western New York were selected for habitat and population measurements. These locations are briefly described below:

Catskills

1. Slide Mountain, Ulster County, off Route 47, near the summit.

This hare habitat consists almost exclusively of balsam fir 3-5 m in height. This type is practically identical with high elevation Base Cover in the Adirondacks and is characteristic of the highest Catskill peaks.

2. Dietz Farm, 3 miles east of Callicoon Center and 4 miles northwest of Youngsville on Route 52, Sullivan County. This is a lowland area overgrown with large, scattered hemlocks and a dense understory of rhododendron and laurel. There are admixtures of yellow birch, red maple, tamarack and blackberry. A large fraction of hare habitat in the Catskills consists of this type.

3. Ice Caves Mountain, summit, Ulster County, near Route 52, about 3 miles southeast of Ellenville. This type is characterised by a shrub-like, open stand of pitch pines with an understory of blueberries. The pines are 3-4 m in height. There are admixtures of paper birch and wild raisin (Viburnum lentago).

4. Ice Caves Mountain, slope adjacent to the area above, but lower down on the mountain slope. Red oak, sassafras and laurels form an admixture with the pitch pine and blueberries.

5. Fir Brook, Round Pond end, Ulster County, off Route 47. This is a ridge top, with large stands of small red spruce and mature hemlock. The cover is very similar to red spruce and hemlock combinations in the Adirondacks.

Western New York

1. Allegeny State Park, "The summit", about 50 m from the tollbooth at the entrance, about 2 miles south of the Allegheny River. This is an

old Scotch Pine plantation (Pinus sylvestris) planted in 1931 or 1932 (49 years old in 1980). The understory is quite open, with a strong invasion of striped maple. There is a thin admixture of yellow birch, beech, white ash, witch-hazel, sassafras and serviceberry. The ecology of this stand is typical of many others like it planted in the early 1930s.

2. Conifer plantation on Old Chautaugua Rd., eastern Chautaugua Co., about 3 miles southeast of Sinclairville. This is a heavily thinned white spruce-jack pine plantation (Fig. 4), planted in 1962 (18 years old in 1980). There is a dense invasion of blackberry (Rubus sp) and arrow-wood (Viburnum dentatum) shrub in the openings. Chokecherry and black cherry are scattered through this open stand.

3a. Conifer plantation on Nobles Rd., eastern Chautaugua Co. about 2 miles southeast of Sinclairville (Fig. 5). This is a closed mature Norway spruce stand, planted in 1946 (34 years old in 1980). The understory is open, with little plant growth. Some red maple, quaking aspen and arrow-wood occupies the few openings.

3b. Conifer plantation on Old Chautaugua Rd., eastern Chautaugua Co., near site 2 above. This is a thinned Norway spruce (Picea abies) plantation, planted in 1965 (approx. 15 years old in 1980). There is a dense invasion of blackberry and arrow-wood in stand openings. Small black cherry trees are scattered through the stand.

4a. Lowland successional forest adjacent to Route 342, a tract of Hammermill Paper Co. property, south of Kabob and west of Sinclairville, Chautaugua Co. This is wet, lowland forest about 20 years old, with large scattered hemlocks (Fig. 6). The stand is composed of red maple,

Figure 4. Heavily thinned white spruce-jack pine plantation (site no. 2), western New York, Chautaugua Co.), with a thick understory of blackberry and strong admixtures of arrow-wood shrub. Site is circled.

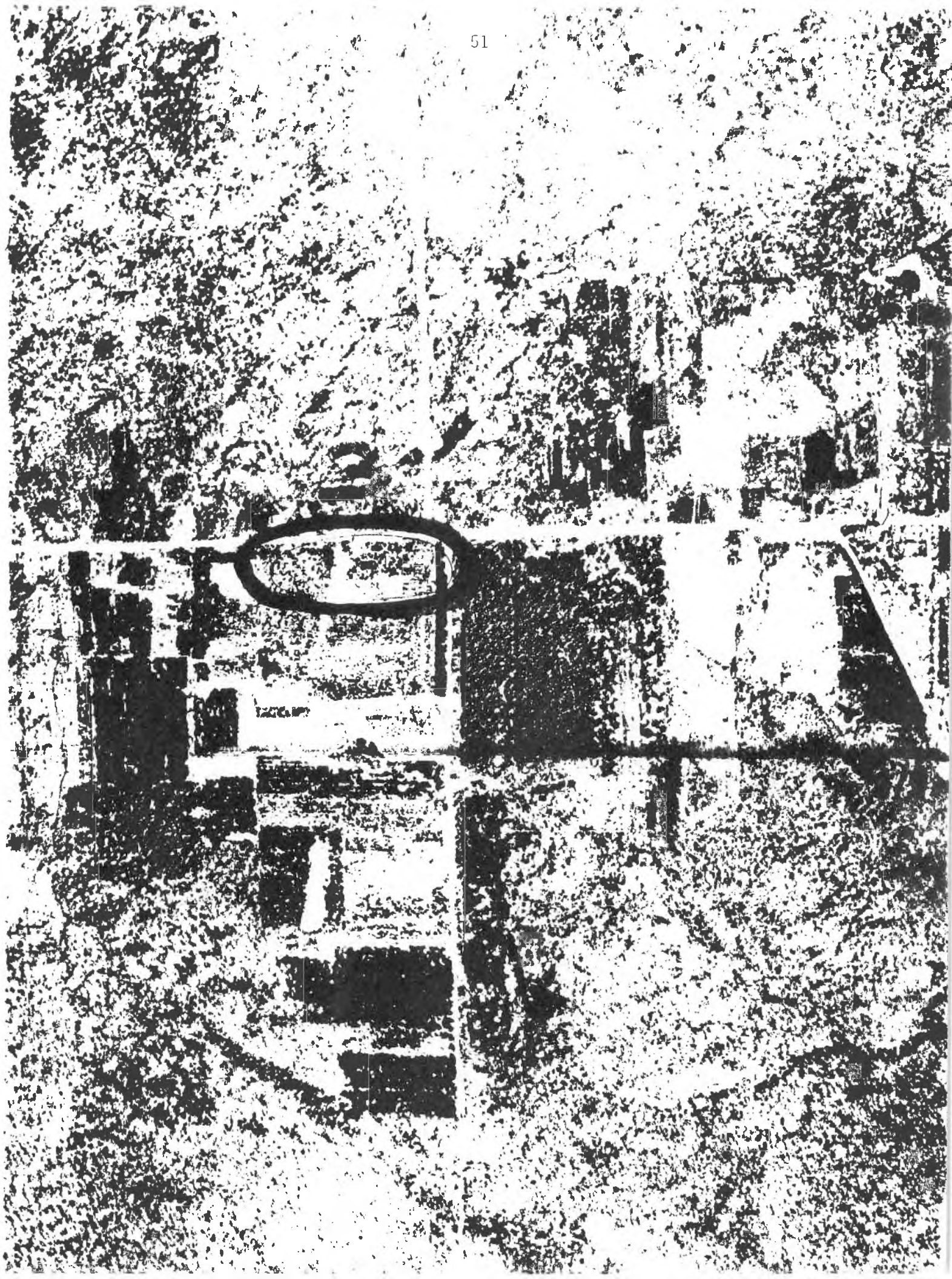


Figure 5. Mature Norway spruce plantation (site no. 3a, western New York, Chautaugua Co.), 34 years old in 1980, with an open understory. Area of measurements is indicated by arrow.

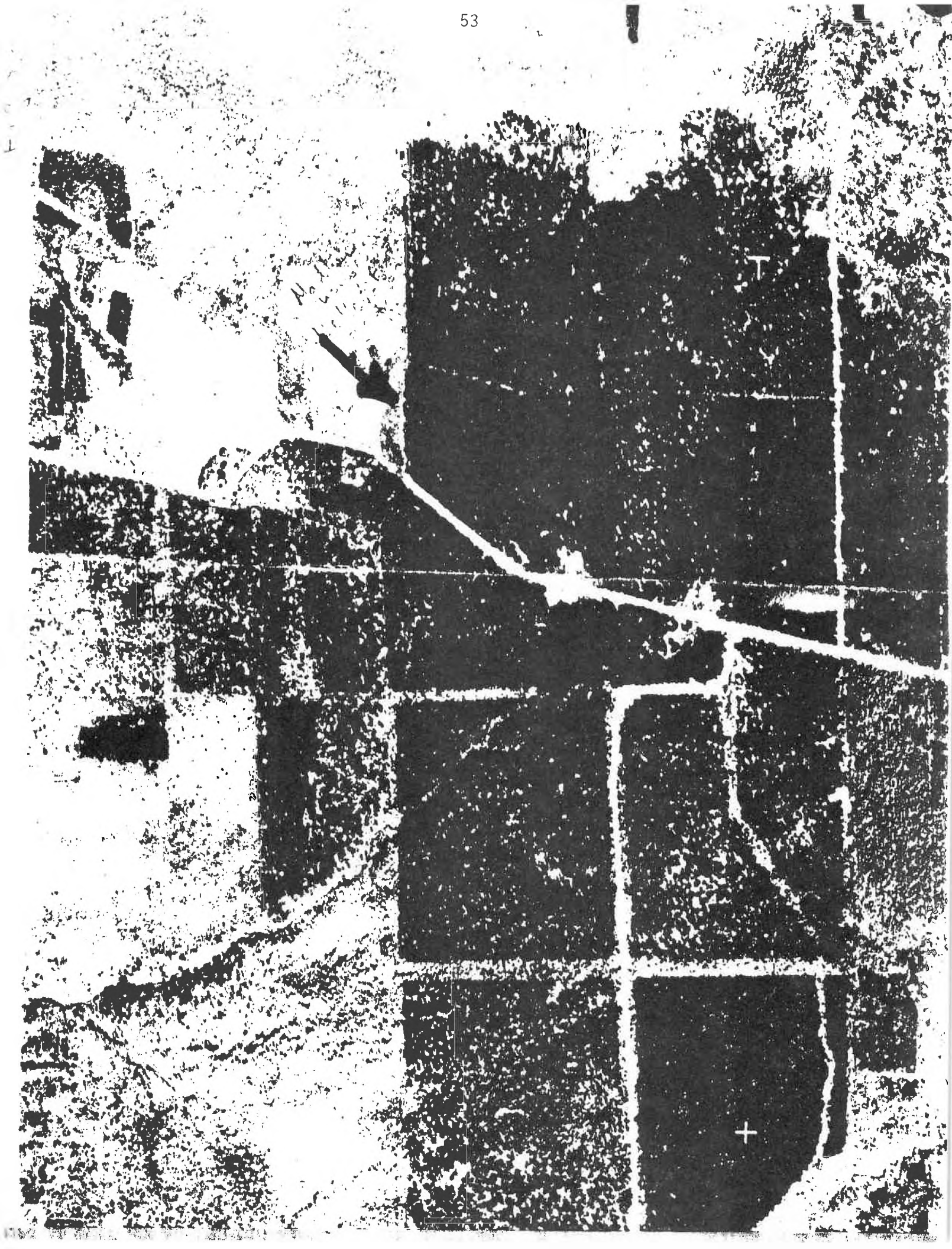


Figure 6. Lowland successional forest (site no. 4a, Hammermill property, Chautaugua Co.), with large scattered hemlocks, and successional forest of red maple, aspen, cherry, and Viburnum shrubs. Route 342 bisects the area. Note open conifer growth along Bear Creek.



1000 1442

D-16
205

← Rte 342

aspens, cherries, and balsam fir with a well developed shrub understory of arrow-wood and wild raisin (Viburnum lentago) Soil is wet and infertile.

4b. Lowland successional forest adjacent to Route 342 (east of site 4b), tract of the Hammermill Paper Co. south of Kabob.

Description is given in 4a.

5a. Successional fields adjacent to plantations of Scotch pine (Pinus sylvestris) and white spruce. These fields were invaded by solid stands of arrow-wood. A few small clumps of white spruce were scattered throughout. The age of the successional shrubs was about 8 years. The adjacent scotch pine plantation was 22 years old (1980).

5b. Successional fields are identical to and near 5a.

Hare habitat characteristics for the Catskill region are given in Table 4. For the Slide Mountain summit (location 1), the mean percent lateral visibility of 3.3 compares to 1.8 for Adirondack Base Cover. Stand height and stem density are likewise similar to Adirondack Base Cover parameters (see Table 1, Appen. 2). Essentially, the vegetation of the Slide Mountain summit location has identical characteristics with similar sites at high elevations in the Adirondacks, with one important difference: the balsam fir type in the Catskills is island-like and much more limited in extent than in the Adirondacks, and hence would support lower hare populations.

The Dietz Farm lowland site (location 2) with laurel and rhododendron in the understory has a combination of characteristics which differs from conifer types. The percent lateral visibility with a mean of 28.4 (Table 4) at 5 m tends to be high, given its mean stem density of 17,375 (Table 4), compared to Adirondack base cover (Table 1, Appen. 2). Indeed, the percent

Table 4. Snowshoe hare habitat characteristics in 3 representative locations in the Catskills (see text).
 Quadrats are 5 x 5 m in size; sample sizes within quadrats are given in the table in parentheses;
 sample sizes of the last 3 columns are means of total counts¹.

Location (Quadrats n)	Percent lateral visibility at various distances $\bar{X} \pm S_{\bar{x}}$			Tree and shrub characteristics $\bar{X} \pm S_{\bar{x}}$			
	5m	10m	20m	Age years	Height m	Diameter cm	stems/ha
1. Slide Mountain Ulster Co. (Balsam fir) (5)	3.3 \pm 0.6 (5)	0.3 \pm 0.2 (5)	0.0 \pm 0.0 (5)	27.8 \pm 2.5 (5)	3.0 \pm 0.2 (42)	4.9 \pm 0.4 (42)	16,640 \pm 2340 (42)
2. Dietz Farm Sullivan Co. Swamp: hemlock, rhododendron, laurel (8)	28.4 \pm 8.3 (5)	7.9 \pm 4.1 (5)	1.1 \pm 0.5 (5)	24.0 \pm 2.5 (5)	2.0 \pm 0.1 (20) (understory)	0.2 \pm 0.7 (20) (understory)	17,375 \pm 4240 (43)
3. Ice Caves Mt. Summit (pitch pine-blueberry) (5)	10.1 \pm 1.1 (5)	1.7 \pm 0.3 (5)	0.0 \pm 0.0 (5)	34.4 \pm 2.4 (5)	2.6 \pm 0.1 (20)	2.5 \pm 0.2 (20)	5682 \pm 1590 (20)

¹ The total number of samples used to calculate each mean can be computed by multiplying the number of quadrats per location (left column) by sample size, (i.e. value in parentheses in table).

Table 5. Snowshoe hare habitat characteristics at 5 representative locations in western New York (see text).
 Quadrats are 5 x 5 m in size; sample sizes within quadrats are given in parentheses; sample sizes
 in the last 3 columns are means of total counts¹.

Location (Quadrats n)	Percent lateral visibility at various distances $\bar{X} \pm S_{\bar{X}}$			Tree and shrub characteristics $\bar{X} \pm S_{\bar{X}}$			
	5m	10m	20m	Age years	Height m	Diameter cm	stems/ha
1. Allegheny State Park Summit (10)	75.4 \pm 2.8 (5)	54.3 \pm 5.1 (5)	25.8 \pm 3.2 (5)	48.5 \pm 0.5 (2)	11.3 \pm 0.1 (10)	8.8 \pm 0.3 (10)	25,560 \pm 1048 (64)
2. Thinned Plantation Old Chautauqua Rd. (10)	7.5 \pm 1.2 (5)	1.6 \pm 0.4 (5)	0.1 \pm 0.1 (5)	17.6 \pm 1.7 (3)	5.3 \pm 0.6 (75)	1.2 \pm 0.6 (75)	30,200 \pm 5565 (75)
3a. Old Plantation Nobles Rd. (10)	62.1 \pm 4.5 (5)	38.1 \pm 4.4 (5)	10.2 \pm 2.5 (5)	33.6 \pm 0.1 (2)	10.8 \pm 0.4 (12)	7.5 \pm 0.5 (12)	8460 \pm 1018 (21)
4a. Successional Forest Kabob, Hammermill (10)	52.9 \pm 4.5 (5)	22.2 \pm 1.9 (5)	9.9 \pm 1.7 (5)	21.2 \pm 3.6 (4)	3.2 \pm 0.5 (36)	1.8 \pm 0.6 (36)	14,520 \pm 2533 (36)
5a. Successional Field Arrowood (10)	38.6 \pm 3.7 (5)	11.3 \pm 2.2 (5)	4.4 \pm 0.9 (5)	14.9 \pm 1.7 (5)	2.1 \pm 0.1 (68)	0.6 \pm 0.03 (68)	24,460 \pm 2773 (68)

¹

The total number of samples used to calculate each mean can be computed by multiplying the number of quadrats per location (left column) by sample size.

lateral visibility at this site is considerably higher than the corresponding value for Adirondack Travel Cover (Table 3, Appen. 2). Hence, one would expect that hare populations in this habitat type would not be high.

The pitch pine - blueberry habitat type on Ice Caves Mountain summit (location 3) has lateral visibility characteristics (Table 4) which are similar to those of Travel Cover (Table 3, Appen. 2) except that visibility declines to 0 at 20 m, a positive characteristic.

In western New York, the habitat examined at the Allegheny State Park summit location (location 1) is an example of hare habitat with extremely poor characteristics. Percent lateral visibility was very high at 75.4% at 5 m, declining to only 25.8% at 20 m (Table 5) which is higher than lateral visibility at 5 m for travel cover in the Adirondacks (Table 3, Appen. 2). It is interesting that the stem density of this site is high, namely 25,560 stems/ha, contributed largely by the striped maple. Nevertheless, this 49 year old plantation is an illustration of hare habitat in its very last stages of value to hares.

The white spruce-jack pine plantation on Old Chautaugua Rd. (location 2, Chautaugua Co.) was apparently heavily thinned for Christmas trees. This thinning has produced an outstanding combination of Base Cover, provided by the conifers, and food provided by blackberry and Viburnum shrubs, in close juxtaposition. While mean lateral visibility of 7.5% (Table 5) at 5 m is higher than Adirondack Base Cover, it declines to 0.1% at 20 m, a positive characteristic. The mean stem density of 30,500 is the highest recorded for any type in New York. The plantation is representative of good hare habitat in western New York. The relative juxtaposition of this plantation with others of various ages and adjacent successional forest is shown in Figure 4.

This aerial photo and others adjacent to it (not illus.) show that plantations in western New York are grouped into blocks which are commonly isolated.

There are tracts of lowland mixed conifer-hardwood forest (i.e. site 4a below) which may serve as avenues of dispersal and movement for hares, but the effect must be weak, compared to the Adirondack region.

The old Norway spruce plantation on Nobles Rd. (location 3a) is a typical example of hare habitat in the very last stages of usefulness for hares. The understory is very open and hare pellets were found in the few places where there was a deadfall or some form of ground cover in the open understory. Parameters of visibility (Table 5), tree height, tree age and stem density are equal to or inferior to equivalent values for Travel Cover (Table 3, Appen. 2). This plantation was located close to others which were younger, in a pattern similar to that of Figure 4. This juxtaposition has undoubtedly been a positive factor in favoring survival of the local hare population nucleus.

The lowland successional forest near Kabob, the Hammermill Paper Company tract, is an example of natural vegetation serving as hare habitat in western New York. Even though cover characteristics are generally poor, equivalent to Travel Cover (compare Table 5 and Table 3 in Appen. 2) in the Adirondacks, this cover type is commonly distributed along lowlands and streams. Conifers are present, but only as a subdued component of the forest. The strong feature of this forest type is the open canopy (due to poor soils) and the understory of shrub viburnums. From the standpoint of long-term survival of snowshoe hares in western New York, this forest type may be extremely important even though it provides only poor quality cover. Its principal value lies in its continuity along streams and lowlands, thus serving as avenues for hare movement and replenishments of depleted populations.

The successional field type, characterized by a heavy growth of viburnum shrubs (location 5a) with scattered small groups of white spruce, adjacent to plantations, is poor habitat judging from the high percent lateral visibility ($\bar{X} = 38.6\%$), even though the stem density is high (i.e. 24,460 stems/ha, Table 5). This type was dissappointing from the standpoint of its suitability as hare habitat. The few hare pellets that were found in these locations tended to be under scattered spruces or spruce clumps. If this habitat type were of higher quality, it would serve as a long-term natural habitat resource to harbor hare populations in western New York. However, its principal value is simply as travel cover, and that only adjacent to conifer plantations.

In sum, the conifer plantations in western New York are serving as hare habitat of intermediate to low quality. Their value is predicated on continuous planting to assure the presence of plantations between approximately 10 and 20 years of age that are ideal for hares. Unfortunately, many plantations in western New York (and in New York State in general) planted during the 1930s and 1940s are now well beyond the stage that is optimum for hares.

The lowland successional forest with open overstory and dense understory of shrub Viburnums is a useful natural habitat type for hares, even though the habitat quality is low. It is particularly useful because it grows along streams and lowlands, creating avenues of continuous cover.

Population Densities in New York State

Population density estimates for various New York locations are based on pellet counts in representative variations of hare habitat in the Adirondacks, Catskills and western New York. Pellet counts were converted to population estimates using a conversion factor developed at the Adjidaumo hare study area

in the central Adirondacks (see Procedures). Results are given in Table 6 and 7. In sum, hare density per pellet counted (in 1 m x 1 m quadrats) is 6.66 hares/mi² or 2.52 hares/km² for the March, pre-breeding population. Factors to convert the March, pre-breeding population to various levels which are characteristic for the annual population cycle are given in Table 8 based on Appendix 3. These conversions are given for various Adirondack locations in Table 11. The reader can make conversions as desired for the Catskills and western New York using Table 8.

Mean March (pre-breeding) population densities for various locations in the Adirondacks are given in Table 9. Locations 1-6 are representative of high elevation sites. The Adjidaumo area is representative of Adirondack lowland sites of mixed forest, including red spruce, balsam fir, hemlock, sugar maple, red maple and yellow birch. Base cover occurs as tracts of red spruce and balsam fir. Estimates of locations 1-7 range from 49 to 228 and represent healthy population levels. Habitat in the High Peaks, composed largely of balsam fir, tends to be in a permanently stunted condition and hence is ideal for snowshoe hares on a continuous basis. This habitat is described by Adams et al. (1920) as follows: "At 4250 ft. the average mature firs approximate 40 to 50 ft. by 8 to 10 inches in diameter at breast height; at timber line they do not exceed 7 to 12 ft. in height by 5 inches (average about 3) in diameter. The change is not uniform and stunting not very noticeable below elevations of about 4500 ft.----. Younger trees, however, are found throughout. Reproduction is abundant in all openings". My personal subjective impressions from trips to the High Peaks region are that above elevations of approximately 2500 ft. (760 m), hare habitat is common and at elevations above 3000 ft. (900 m) hare habitat is essentially continuous. The High Peaks habitat and larger tracts of base cover at lower elevations,

Table 6. Snowshoe hare pellet counts in the Adjidaumo hare census area. Ten quadrats (1 m²) were tallied in each of 10 locations between May 23 and May 26, 1978. The population estimated by removal (ending April 1) was 50 hares.

Location	Pellet Count Pellets/m ² $\bar{X} \pm S E (n)$
1	22.3 \pm 13.9 (10)
2	20.7 \pm 12.8 (10)
3	11.9 \pm 7.2 (10)
4	24.3 \pm 13.6 (10)
5	15.9 \pm 6.7 (10)
6	68.7 \pm 44.9 (10)
7	44.4 \pm 22.3 (10)
8	34.6 \pm 30.2 (10)
9	29.6 \pm 16.3 (10)
10	28.1 \pm 15.9 (10)
\bar{X} (SE) of sample means = 30.0 (5.2)	

Table 7. Conversion factors relating the mean pellet count (from Table 3) to the snowshoe hare population density on the Adjidaumo hare census area.

Parameter	System of Measurement	
	English	Metric
Hare population estimate	50	50
Total area, Adjidaumo	0.25 mi ²	0.66 km ²
Mean pellet count	30/m ² (metric)	30/m ²
Hare density	200 hares/mi ² of hare habitat	75.7 hares/km ² of hare habitat
Hare density per pellet counted	6.66 hares/mi ²	2.52 hares/km ²

Table 8. Computed values from a snowshoe hare population model, showing the annual cycle beginning with a pre-breeding population of 100 animals. (From FINAL REPORT, W-105-R, Jobs IX 1-3, p. 31). Factors relating monthly population levels to the March population level are based on the model.

Month	Population	Factor
March	100	<u>1.0</u>
April	94	0.9
May (Litter 1)	173	1.7
June (Litter 2)	283	2.8
July (Litter 3)	314	<u>3.1</u>
August	278	2.8
September	246	2.5
October	219	<u>2.2</u>
November	205	2.0
December	192	<u>1.9</u>

Table 9. Mean snowshoe hare pre-breeding (March) population densities estimated for the Adirondack region¹. Most estimates are based on pellet counts (see text). Locations are discussed in the text.

Adirondack Location	Pellet Count ² $\bar{X} \pm SE$ (n)	Estimated Hare Density hares/mi ² (hares/km ²)
1. Goodnow Mt.	33.1 \pm 8.4 (10)	220 (83)
2. Santanoni Mt.	17.0 \pm 2.5 (10)	113 (43)
3. Kempshall Mt.	34.3 \pm 6.1 (5)	228 (86)
4. Seward Range	7.4 \pm 3.4 (5)	49 (19)
5. Marcy-Skylight	17.2 \pm 6.6 (3)	114 (43)
6. Whiteface Mt.	22.6 \pm 4.7 (8)	150 (57)
7. Adjidaumo Area	30.0 \pm 5.2 (10)	200 (76)
8. Hyslop Area		435 (165)

¹ Elevations for sites are given in Table

² The (n) value is the number of means used to calculate the value given. Each mean was derived from 10 (1m x 1m) quadrat counts. Thus, (10) represents 100 quadrat counts.

Table 11. Computed snowshoe hare densities for hare habitat at high elevation sites in the Adirondacks.

Densities were estimated from hare pellet counts given in Table 2 and conversion values given in Tables 4 and 5.

Location	Elevation of sites ft (m)	Estimated hare densities, hares/mi ² (hares/km ²)			
		July ¹	October ²	December ³	March ⁴
1. Goodnow Mountain	2690 (315)	683 (258)	485 (133)	418 (158)	220 (83)
2. Santanoni Mountain	2700-3000 (818- 909)	351 (133)	249 (94)	215 (82)	113 (43)
3. Kempshall Mountain	2360-2800 (715- 848)	708 (268)	502 (190)	433 (163)	228 (86)
4. Seward Range	3000-3900 (909-1182)	152 (58)	102 (41)	93 (36)	49 (19)
5. Marcy-Skylight Mountains	4350(1318)	355 (134)	252 (95)	217 (82)	114 (43)
6. Whiteface Mountain	4200-4800 (1273-1454)	466 (176)	331 (125)	285 (108)	150 (57)
Mean	-	453 (170)	321 (121)	277 (104)	146 (55)

¹Density computed by multiplying March density by 3.1 (See Table 5).

²Density computed by multiplying March density by 2.2.

³Density computed by multiplying March density by 1.9.

⁴Density computed by multiplying pellet counts in Table 4 by 6.66 hares/mi² or 2.52 hares/km².

Table 10. Mean snowshoe hare pre-breeding (March) population densities estimated for the Catskill and western New York regions. Estimates are based on pellet counts (see text). Locations are discussed in the text.

Region and Location	Pellet Count ¹ $\bar{X} \pm SE$ (n)	Estimated Hare Density hares/mi ² (hares/km ²)
<u>Catskills</u>		
1. Slide Mountain	6.1 \pm 1.9 (5)	40 (15)
2. Dietz Farm	4.7 \pm 2.1 (8)	31 (12)
3. Ice Caves Mountain	4.3 \pm 0.9 (5)	28 (11)
4. Ice Caves Mt. slope	2.2 \pm 0.6 (10)	14 (6)
5. Fir Brook	13.0 \pm 2.7 (5)	86 (33)
<u>Western New York</u>		
1. Allegheny Park, Summit	0.2 \pm 0.1 (10)	1.3 (0.5)
2. Plantation, Old Chat. Rd.	3.5 \pm 1.1 (10)	23 (9)
3a Plantation, Nobles Rd.	0.2 \pm 0.1 (10)	1.3 (0.5)
3b Plantation, Old Chat. Rd.	2.4 \pm 0.9 (10)	16 (6)
4a Kabob, Hammermill Prop.	0.3 \pm 0.2 (10)	2 (0.7)
4b Kabob, Hammermill Prop.	0.5 \pm 0.3 (10)	3.3 (1.3)
5a Successional Field No. 1	0.01 \pm 0.01 (10)	0.07 (0.02)
5b Successional Field No. 2	2.3 \pm 0.4 (10)	15 (6)

1

The (n) value is the number of means used to calculate the value given. Each mean was derived from 10 (1m x 1m) quadrat counts. Thus, (10) represents 100 quadrat counts.

particularly in logged areas constitute the best habitat in New York State. An extremely high hare density can be attained in limited tracts of ideal cover (Base Cover) as in location 8. This density of 435 hares/mi² (165/km²) in March, translates to an October density of 957 hares/mi² (363 hares/km²) which is equivalent or higher than the highest values reported for Alaska, Alberta, Newfoundland, Minnesota or Ontario (Keith and Windberg 1978, p. 51). It is interesting that these high New York densities are achieved by the low reproductive rate of 6.53 hares/female/year.

By contrast, the population levels in the Catskills are lower (Table 10). Population levels at Slide Mountain, Ice Caves Mountain and Fir Brook are respectable and represent healthy populations. Indeed, the technicians observed hares on several occasions on roads through the pitch pine-blueberry type on Ice Caves Mountain. Cottontail rabbits were also present on Ice Caves Mountain.

The populations in the best western New York locations are moderate to low by Adirondack or Catskill standards (Table 10). The population levels at 2 plantation sites (locations 2 and 3b) and the successional field associated with a plantation (5b) represent huntable populations. However, the other 5 values represent ailing or dying populations. It is apparent from these data that hare densities adequate to support hare hunting in western New York can be attained only by vigorous management for the ideal size classes of conifers. The data in Table 10 and my general impressions from field trips suggest that hare populations in western New York are declining in general, coinciding with the current predominance of aging conifer plantations. Indications are that this trend in western New York populations is inexorable and will probably not be arrested or reversed without vigorous conifer stand management favoring the production of stand age classes that provide good hare habitat.

The population data presented for western New York are readily applicable, in my opinion, to conifer plantations and successional sites west of the Catskill Mountains and to central New York. In sum, the picture of declining hare populations appears to be a general one, west of the Catskill Mountains. To a large extent, the presence of hares in this region is a man-contrived phenomenon dependent largely on non-reproducing conifer forest stands, also developed by man. Unfortunately, it appears that the hares have not utilized native successional types (with the possible exception of the lowland forest represented on location 4a and 4b) to any large degree. Thus, huntable (i.e. strong) populations will owe their future presence to long term programs of conifer stand management.

Habitat Management for Hunting and Viewing

Details of habitat management in general are given in Appendix 2. Details on habitat management for viewing are given in Appendix 4. A summarizing discussion is presented here.

Important habitat management measures to maximize hare populations and to enhance the activities of hunting and viewing hares are:

1. Manage conifer stands for the presence of optimum cover, which I have termed Base Cover. In closed stands, base cover is provided by conifer trees approximately 2.5 to 4.5 m in height. Above that height, self pruning opens up the understory destroying the obstruction to vision (or increasing lateral visibility) which decreases the quality of the habitat for hares. Thus, the principal ingredient is dense cover close to ground level. One way of maximizing the life of conifer plantations as hare habitat is to thin the plantations at those critical times when self-pruning is

about to occur. For example, when the lowest branches of conifers touch in the rows, alternate rows can be eliminated in each direction. Trees under this management scheme will grow full and be ideal as Christmas trees. Obviously, this type of management is not compatible with timber production. A stand managed in this way is theoretically productive as Base Cover for the natural life of the stand. Additionally, browse produced between conifers provides ideal juxtaposition of cover and food. In central and western New York, such stands will be occupied by both cottontails and snowshoe hares.

2. Manage conifer stands and potential intervening stands of mixed forest and brush to provide continuous avenues for hare travel.

Unlike the cottontail rabbit, hares do not normally cross open areas or open forest. Isolated tracts of hare cover are islands which render the population subject to extinction by hunting, predation and other factors. Conifer stands (or other adequate forest cover) managed in blocks with the corners touching will insure cover continuity. This characteristic cannot be overemphasized.

3. Ideally, the depth of continuous conifer stands should not be great (i.e. over 200 m) from any one edge. Hares find browse beyond the edge of monolithic conifer stands and therefore the center of such stands will be underutilized. This problem can easily be mitigated by creating openings in large stands, or thinning throughout the stand as described above.
4. Browse should be readily available adjacent to conifer hare cover.

As mentioned above, browse can be created within stands by thinning

or creating small openings. Cutting at the edge of conifer stands will produce ample browse. As approximately 70% of all hare activity is confined within a strip 30 m from the edge, managing for browse beyond that strip has little value.

5. To enhance hare viewing, mowed grassy openings adjacent to conifer cover will provide opportunities to observe hares feeding in spring and early summer (hares do not normally enter openings in fall or winter). As hares tend to feed in openings, close to conifer cover (mean distance 2.0 m), mowed roadside strips need not be wide for hares. The dynamics of hare-human interaction in viewing are modeled in Appendix 4. The approximate relationship of road frontage or opening depth to the length of edge bordering the opening is given by the formula:

$$F = H (20 \text{ m})$$

where F equals road frontage and H is equivalent to the number of hares using the opening. For example, at a selected observation probability level of 0.8 (Table 11, Appendix 4) and an observation period of 10 minutes, a "6 hare opening" would be required and the road frontage of such an opening would be 120 m. Observation of hares in residential lawns is readily possible where lawns are directly adjacent to conifer cover occupied by hares. The probability of seeing hares in openings is enhanced during the evening feeding period after 7:00 p.m. In sum, hare management for viewing falls into 2 categories, namely (1) hare observation in residential lawns in sparsely or moderately settled forest land within hare range and (2) hare observation along roadsides and in forest openings (for details, see Appendix 4, p. 54-61).

Producing snowshoe hare habitat (i.e. conifer stands) can be accomplished by (1) planting conifers where they do not normally reproduce by natural means, e.g. in central and western New York, (2) by ground scarification adjacent to existing conifer stands, especially in areas where conifers do not easily reproduce (this technique has been successfully used in central New York (Region 7) by J. Proud (J. Proud, pers. comm.), and (3) by cutting and thinning in existing mixed stands of hardwoods and conifers within snowshoe hare range.

From a practical standpoint, the latter technique must be commercially feasible. An experimental cut on 10 acres of the 146 acre Adjidaumo Hare Management Area on Huntington Forest (central Adirondacks) was commercially contracted in 1976. The objectives of this commercial cut were to determine whether biological requirements of hares as well as hunter requirements for huntable cover could be met by commercial logging. The forest composition in terms of timber production before cutting was measured by 10 prism cruise plots. Results are given in Table 12. Post logging composition was estimated from trees marked for cutting. In general, logging of the hardwood overstory was successfully conducted with a minimum of damage to interspersed patches of red spruce and balsam fir. Logging was done in summer so that soil disturbance would enhance conifer reproduction. In general, it appeared that logging of larger overstory hardwoods was successfully conducted with a minimum of damage to interspersed patches of red spruce and balsam fir, while also providing strips of continuous cover between residual patches.

According to several recent subjective inspections by R. Sage (pers. comm. 1982), approximately 50 percent of the forest openings created in the hardwood portions of the stand have been densely colonized by balsam fir (2 to 4 ft. in height) and red spruce (up to 1.5 ft. in height). Hardwoods are dominant in the remaining openings with conifers scattered throughout. Hardwood reproduction on this wet site is primarily composed of yellow birch and

Table 12. Basal area of timber and tree size classes on the Adjidaumo Hare Study Area given by 10 prism cruise plots, before logging. Post logging basal areas are estimates based on timber marked for cutting.

Species	Large Sawtimber 16.5 in +		Small Sawtimber 10.5 - 16.4 in		Pole Size 4.5 - 10.4 in		Saplings 0 - 4.4 in	
	Before logging sq.ft/ acre	After logging sq.ft/ acre	Before logging sq.ft/ acre	After logging sq.ft/ acre	Before logging sq.ft/ acre	After logging sq.ft/ acre	Before logging sq.ft/ acre	After logging sq.ft/ acre
Beech	4.5	0	8.0	0	1.5	1.5	3.5	3.5
Yellow Birch	7.0	0.5	12.0	9.0	4.0	4.0	1.0	1.0
Red Maple	2.0	0	4.0	3.0	3.5	3.5	0.5	0.5
Sugar Maple	1.5	0.5	3.5	3.0	1.0	1.0	0.5	0.5
Red Spruce	0	0	3.5	3.5	12.0	12.0	26.0	26.0
Hemlock	0	0	1.5	1.5	0	0	0	0
Balsam Fir	0	0	0	0	1.0	1.0	0.5	0.5
Total ¹	15.0	1.0	32.5	20.0	23.0	23.0	32.0	32.0

¹Total removal of large sawtimber and small sawtimber was 46 percent. There was no removal of saplings and pole size timber. On the basis of the entire stand, total removal was 26 percent; 74 percent of the total basal area remained uncut.

red maple. At this early date, raspberry and blackberry shrubs are still prominent in all openings. It appears from this limited experimental cut that Adirondack mixed hardwood conifer stands can be commercially managed to enhance conifer hare habitat.

Prescription of precise forest management schemes is not appropriate or practical in terms of snowshoe hare management objectives alone. (In any case, such schemes can be readily developed on the basis of the management guidelines presented here. Management guidelines are given by Brocke 1975 (Appendix 2) Myers 1982 (Appendix 5, Item 7). In practice, forest land in any region is managed for a variety of objectives and may be managed for a variety of wildlife species. Where the inclusion of hare management is appropriate, hare management can be integrated into an overall plan for various species and compromises can be readily made (See Brocke 1977, Item 5, Appendix 5).

For the individual manager of forest and wildlife resources who actually manages wildlife habitat, whether this person is termed a "wildlife manager" or "forester", it is essential that he/she knows what the principles of habitat management are for important species, rather than blindly follow management (cookbook) prescriptions. Forest succession and local habitat conditions are usually so diverse that management schemes had best be developed locally by individual technicians. But, it is essential that those technicians (1) know for which wildlife species habitat management techniques have been developed, (2) know what the techniques are for a given species, and (3) are willing to be creative and responsible for developing integrated habitat management programs. Obviously, management of wildlife and forest resources at the level of the practicing technician (i.e. forester or wildlife manager) will be only as good as the administrative leadership of agencies will encourage it to be.

The snowshoe hare is one species that is relatively unresponsive to centralized regulatory management and relatively responsive to habitat management at the local level. Consequently, the expertise and active participation of local managers (wildlife managers, foresters and technicians at the DEC Regional level, as well as managers of private lands) is most important. This expertise can be encouraged and enhanced by workshops, participation at conferences and the administrative freedom and encouragement to practice habitat management at the local level.

SECTION 4. HARE HUNTING AS A SPORT

Factors affecting the success and behavior of hare hunters were studied in 27 experimental hunts conducted at Huntington Forest during the 1975-76 and 1976-77 hunting seasons. Additionally, the records of a 10 year diary of a northern New York hare hunting party are compared here with the experimental hunt dates. Participation of hunters was solicited through newspaper articles, an article in *Outdoor Life*, a talk at a Conservation Council meeting, talks at Federation meetings and personal contacts. Almost all hunters came from southeastern and northeastern New York.

During the 1975-76 season, the mean age of hunters in this (limited) sample was 37.7 years ($n = 39$, $s = 12.7$) while the mean number of years of experience was 16.6 years ($s = 15.2$). In the 1976-77 season, the mean age was 37.2 ($n = 35$, $s = 14.8$) while the mean number of years of experience was 9.8 ($s = 9.4$). The mean age of these hare hunters is almost identical with the mean age of New York hunters in general (37 years) as determined for the 1970-71 season (Marsters 1978) and younger than the mean age of 39 years determined for New York hunters in the 1975-76 season (Decker and Brown 1979). The mean age of the Huntington sample is somewhat higher than U.S. small game hunters in general; according to the National Survey of Hunting and Fishing (National

Analysts 1975), 63 percent of all U.S. small game hunters are under 34 years old. In sum, the high mean age of New York hare hunters is not distinctive compared to hunters in general, reflecting a low recruitment rate of young hunters in general.

The success rate and other parameters for the experimental hunts are given in Table 13. The average number of hunters per hunt is approximately 5. About 4.5 hours were spent hunting and approximately 2 dogs accompanied each group. The average number of hares bagged per party barely exceeded 1 hare (Table 13). It is of considerable interest to compare the success rate of the Huntington hare hunting groups with that of a remarkable northern New York hare hunting group. For over 10 years, this group recorded hunt statistics in a diary; these data are summarized in Table 14. While the number of hunters per hunt (4.5) for Paye's hunting party was similar to Huntington parties (Table 13), the success rate was not. The hares bagged per hunt by Paye's party was 5.3 hares (205 hunts), versus 1.3 hares per hunt in 1975-76 and 1.0 hares per hunt in 1976-77 for Huntington parties. The mean number of hares bagged per hunter per hunt was 1.3 for Paye's party versus 0.3 (1975-76) and 0.2 (1976-77) for Huntington groups. The success rate of Paye's group was 4 to 6 times as great as the Huntington hunt groups. As a "control", Paye's party was invited to Huntington Forest to hunt; the party bagged 7 hares in 3 hours, by far the highest success rate of any group. The success rate of hare hunters is apparently lower compared to cottontail rabbit hunters, according to the findings of Schierbaum and Alkon (1963). While the average number of hunters per rabbit hunting party was only 2 (and 2 dogs), the mean number of cottontail rabbits bagged per hunt was 1.89 (Schierbaum and Alkon, 1963).

Each hunting party was accompanied by an observer (including the author); our observations of hare hunters and hunts are revealing. In general, it

Table 13. Statistics for experimental hare hunts on the Adjidaumo Hare Study Area in the central Adirondacks.

Hunting Period	Total hunts (n)	Hunters per hunt $\bar{x} \pm SE$	Hours per hunt $\bar{x} \pm SE$	Hunter hours per hunt $\bar{x} \pm SE$	Dogs per hunt $\bar{x} \pm SE$	Hares seen per hunt $\bar{x} \pm SE$	Shots fired per hunt $\bar{x} \pm SE$	Hares bagged per hunt $\bar{x} \pm SE$
Dec. 15, 1975								
to Mar. 14, 1976	20	4.4 \pm 0.4	4.7 \pm 0.3	21.6 \pm 2.7	1.9 \pm 0.3	5.1 \pm 1.0	3.6 \pm 0.9	1.3 \pm 0.44
Jan. 8, 1976								
to Mar. 10, 1977	7	5.3 \pm 2.4	4.4 \pm 0.3	23.6 \pm 4.2	1.8 \pm 0.5	4.0 \pm 2.0	-	1.0 \pm 0.6

Table 14. Summary of hunting success of the hare hunting party of John Paye, Paul Smiths, New York. These data are from a diary covering 10 years. Hare hunts were conducted in the Adirondack region, particularly Jefferson County.¹

Hunting Season	Hares bagged (n)	Hunts (n)	Hunters per hunt(\bar{x})
1967-68	85	15	4.8
1968-69	145	24	3.9
1969-70	100	23	4.3
1970-71	68	17	6.9
1971-72	95	13	4.5
1972-73	183	26	4.8
1973-74	160	27	4.9
1974-75	93	28	3.4
1975-76	93	16	4.7
1976-77	61	16	3.1
Total $\bar{x} \pm s$	108.3 \pm 40.4	20.5 \pm 5.6	4.5 \pm 1.0

¹

Diary supplied by John Paye.

appeared that hare hunters and their dogs fell into 3 categories, namely:

(1) Inexperienced hunters with inexperienced and ineffective dogs, (2) Experienced hunters and their dogs who had hunted open, broken up hare coverts (such as those that occur in Jefferson and St. Lawrence Counties) into which the dogs were released, driving hares into openings to be shot by hunters; dogs belonging to such groups were often unable to bring hares full circle in the dense cover of the study area (the study area and trails are illustrated in Fig. 7), (3) Experienced hunters and their dogs who were used to hunting dense stands of conifer cover (like John Paye's group). Dogs of such parties could effectively bring hares full circle to the waiting hunter. It was also apparent that the trails were too far apart in the Adjidaumo area, namely 250 to 300 m apart. A distance of approximately 100 to 150 m between trails would have enhanced deployment and effective placement of hunters. Additionally, hunters complained about lack of openings.

Observations on weather and snow conditions were categorized for hunts in 1975-76 and related to hare hunting success criteria. The results are given in Table 15. Conditions were judged (by the Huntington observer) to be "poor" when temperatures were extremely cold, when it was raining or when sinking depth of hunters with snowshoes exceeded 1 ft. (.3 m). Conditions were judged to be "good" when sinking depth was minimal allowing hunters and dogs to move around easily, when some fresh snow indicated the passage of hares and allowed the effective placement of hunters and when the weather was pleasant. Moderate conditions fell in between. Comparison between means ($t = 3.0$, 95% confidence) indicated that more hares were seen and bagged under good conditions than under poor conditions. Also, there is a significant difference ($t = 3.47$, 95% confidence) between the means of hares bagged under "good" and "moderate" (lumped) versus "poor" conditions (Table 15). Thus, it appears that adverse weather and poor snow conditions tend to decrease hunting success. We also observed that most

Figure 7. Diagram of hare hunting trails on the Adjidaumo Experimental Hare Hunting Area, Huntington Forest in the central Adirondacks. Dots are trail markers. The total length of the trails is 5350 m.

NORTH BOUNDARY TRAIL
(LOG RD.)

DIRT ROAD

EXPERIMENTAL
AREA

A

B

C

D

E

SOUTH BOUNDARY TRAIL

0 100' 400' 800'

SCALE -- 1/4" = 100'

TRAIL MARKERS
25 M. APART

N

82

PARKING
LOT

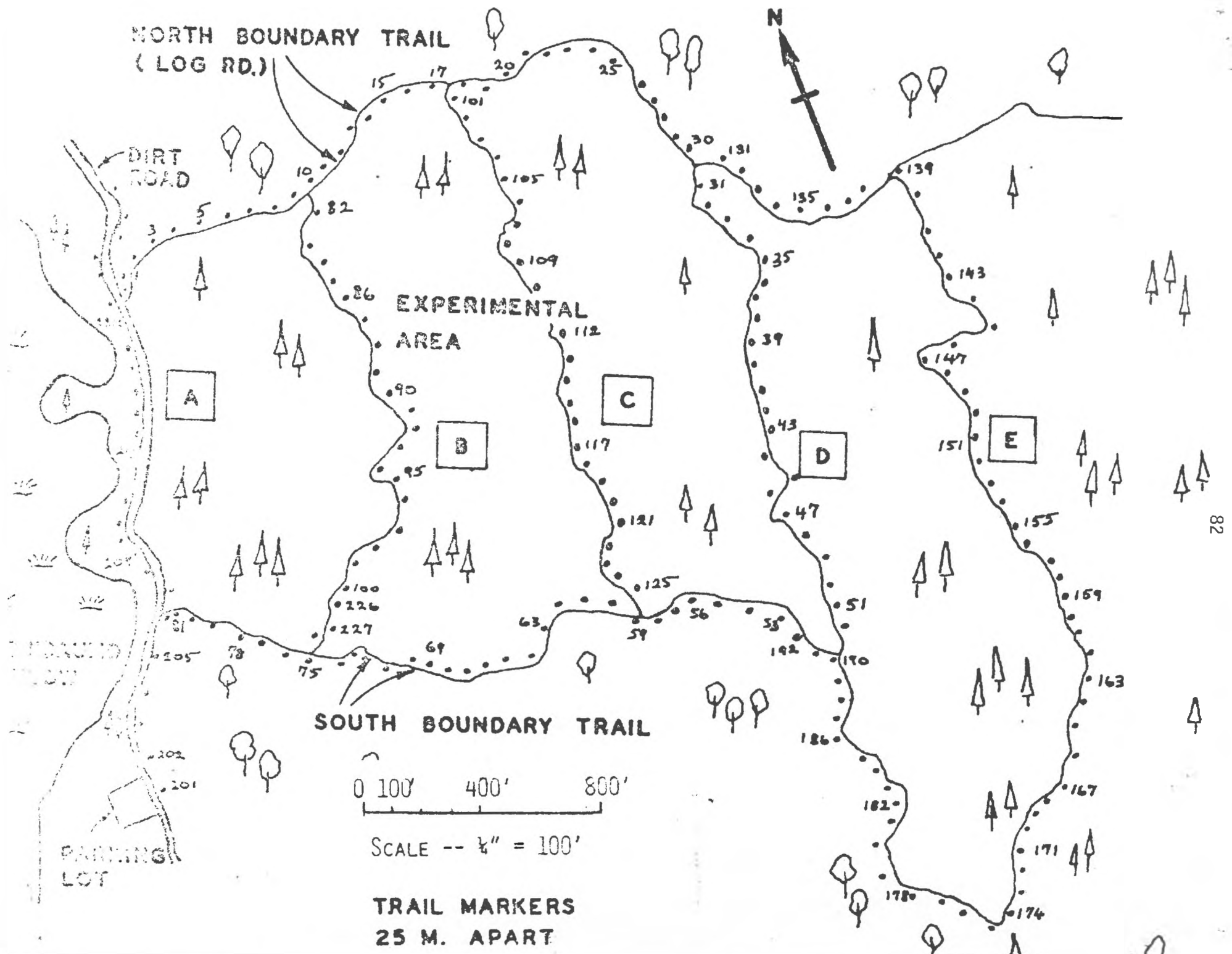


Table 15. Hares seen and bagged under "good," "moderate" and "poor" weather and snow conditions.¹

Characteristics	Statistic		
	n	\bar{x}	s*
Hares seen per hunt under -			
Good conditions	5	9.4	5.2
Moderate conditions	8	5.0	4.5
Poor conditions	7	2.1	1.9
Hares bagged per hunter under -			
Good conditions	5	3.2	2.8
Moderate conditions	8	1.4	1.5
Poor conditions	7	0	0

¹See text for description of categories.

*Standard deviation

hunters made a special effort to hunt when large numbers of hare tracks were visible in the snow (e.g. following several days of no snowfall). However, most hunters (excepting very experienced ones) tended to decrease their efforts markedly when few hare tracks were visible (e.g. as often happens after a fresh snowfall), and tended to blame their lack of success on the lack of hares in the study area.

Current data on the level of hare hunting are not available. However, I estimated the level of hare hunting in the Tug Hill area (Brocke and Zarnetske, 1974) on the basis of DEC survey statistics compiled for 1966-67 (See Table 16). On the basis of Table 16, hunters spent 270,631 days afield hunting hares in New York during the 1966-67 season (Table 16), which is 30 percent of the total number of days afield hunting squirrels (Table 43, Brocke and Zarnetske, 1974) and 18 percent of the total number of days afield hunting ruffed grouse (Table 40, Brocke and Zarnetske, 1974). A conservative estimate of expenditures of hare hunters in the Tug Hill area (30,000 days spent afield) for the 1966-67 season is \$226,700 (Brocke and Zarnetske 1974), on the basis of an expenditure of \$7.62 per day per hunter (small game, U.S. Dept. Interior, 1972).

In sum, the mean age of hare hunters of approximately 37 years is almost identical to the mean age of New York hunters in general. If this age is considered to reflect a low recruitment rate of young hunters, correction of the problem, if it can be done, must be part of a much broader effort. Hare hunters in general tend to be less successful than cottontail rabbit hunters, although dedicated hare hunters tend to have consistently high success. Hunting trails greatly aid deployment of hunters and adverse weather and deep snow tend to depress hunting success markedly. Hunters tend to hunt harder when hare tracks are visible in the snow. Days spent afield hunting hares in 1966-67 was approximately 30

Table 16. Snowshoe hare hunting statistics, for 1966-67¹, based on Brocke and Zarnetske (1974), "Resources of the Tug Hill Region".

1966-67 statistics					
Kill parameter	Jefferson County	Lewis County	Oneida County	Oswego County	New York State
Hunters	4,031	4,154	3,324	3,416	-
Days afield	13,608	21,161	21,834	13,730	270,631
Hares taken	12,635	22,080	14,214	8,423	193,487
Hares/hunter/day	0.92	1.03	0.64	0.61	0.71

¹

Based on statistics and data compiled by the New York State Department of Environmental Conservation titled "Standard Errors of Estimate of Take and Days Afield". The Department used expansions from survey samples for its information.

percent of the level for squirrels and 18 percent of the level for grouse.

SECTION 5. MANAGEMENT OPTIONS

The management options and considerations discussed below reflect my own (limited) perspectives of factors underlying the pattern of state small game management regulations. The task of integrating perspectives on hare management presented here with management considerations for other small game species falls properly within the purview of DEC wildlife managers and administrators. I have attempted to take the broad view and hopefully provide some useful philosophical as well as technical perspectives as a basis for making hare management decisions. I assume that the reviewer has read the text and Appendices in this report. These materials will not be referred to specifically in this section.

It seems that management of the snowshoe hare resource in New York State falls into two main regional categories, namely (1) management of the snowshoe hare resource in the Adirondack region where hare populations tend to be strong and conifer cover reproduces naturally in most situations; (2) management of the hare resource in the Catskills, central and western New York where hare populations tend to be weak and are subject to overexploitation, and where conifer cover frequently does not reproduce naturally.

Management in the first category requires little comment. In my opinion, dates for the snowshoe hare hunting season in northern New York, namely October 1 to March 13 (New York State Regulations Guide, 1932-83) take advantage of strong populations and do not impinge on the breeding season. Even though late winter hunting may deplete local populations, this depletion will be temporary in most cases as continuous hare cover of high quality fosters replenishment. The current bag limit of 6 hares per person per day will rarely be achieved, even by the best hunters. This generous bag limit probably serves as an inducement to hunt hares. In short, the current regulations seem to be ideal.

The principal problem in the Adirondack region vis à vis the hare resource is its current under-utilization. The latter appears to be a function of

changing recreational patterns and a lack of recruitment of young hunters. There is potential for attracting hunters to the Adirondack region. The Small Game Hunting Guide issued by the N.Y.S.D.E.C. under the "I love New York" campaign is a good start in this direction. Additional guides might be issued by Adirondack chambers of commerce. Perhaps the best solution would be a substantial hunting guide for the Adirondack region as a whole, issued jointly by Adirondack hamlets and towns in an integrated P.R. campaign (such campaigns have been discussed but not implemented by local towns and hamlets). Snowshoe hare management on private lands will require the kindling enthusiasm among private land managers. This may be difficult at best in the central Adirondacks where hare hunting with dogs conflicts with wintering deer in conifer deer yards. (It has been my observation that many, if not most, hare dogs pursue deer despite the contentions of dog owners). And, from an economic standpoint, deer are the principal wildlife resource in the Adirondacks. However, in the peripheral Adirondacks where deer are scarce, this conflict is not serious at present. Additionally, much of the best hare cover from the standpoint of hunting ease is located in the Adirondack periphery.

The principal problems in terms of hare management in New York state center on the Catskill, central and western New York regions, as reflected by the current presence of 3 different open seasons, closed seasons in 3 regions and a current daily bag limit of 2 hares. A cogent question is: Under what management options can hunting be accommodated where hare populations are weak and subject to over-harvest? (e.g. particularly in central and western New York). Following is a brief consideration of current regulations:

1. A short season in early winter, e.g. Dec. 27 to Jan. 30, current season in southwestern New York. Such a season tends to put perceived management emphasis in the wrong place vis a vis the sportsman/sportswoman, who infers that the short season will effectively enhance local hare populations (especially when the season is coupled

with a small bag limit). Emphasis is detracted from the principal problem, namely deteriorating habitat which will tend to diminish hares in the long term, regardless of regulations.

2. A moderately long season, e.g. Dec. 15 to Feb. 28 or Jan. 10 to Feb. 28 as in central New York and the Catskill region. There is effectively no biological advantage by postponing the starting date to January 10. Hence the opening date might be moved forward to mid-December. An opening date of December 1 is biologically feasible, but hare hunting activity might conflict with deer hunting. The only biological problem with an early hare season in more southerly segments of the hare's range is its color change when snow may not be present, making it more vulnerable. However, the December 15 date should be late enough to pose no vulnerability problem in most years. The February 28 closing date, coinciding with the closing date of the cottontail rabbit season is an excellent choice.
3. A small daily bag limit, e.g. 2 hares in regions south of the Adirondacks. The small daily bag limit has psychological value, rather than a real biological value. A low bag limit will suggest to the responsible hunter that hare populations are vulnerable in the region. From that standpoint, it has definite value. However, a small bag limit will have little or no actual effect in reducing the take of hares. Firstly, most hunters would not be capable of filling a larger bag limit. Secondly, I have observed that in those few cases when the individual take for the day exceeds the bag limit, the extra hares are spread over the bag limits of other party members (it happens with deer; hares are no exception).
4. Closure of the hunting season, e.g. as is currently the case in west-central New York. This is a two-edged sword. In the short term, such

a season may have a positive effect in saving a few very vulnerable populations, especially if they are isolated, and especially if the local hare hunting clientele is supportive. On the negative side, weak hare populations will not be saved in the long run by season closure, when continued habitat deterioration is the principal cause of population decline. Also, season closure (in the absence of habitat management programs) builds false hope that regulation will strengthen weak populations. Finally, season closure slowly dries up the hare hunting clientele.

In sum, it is probable that restrictive regulations per se will not prevent local extinction of weak hare populations, when that weakness is a consequence of deteriorating habitat. And, restrictive regulations have a debilitating effect on the sport of hare hunting in general. It should be noted that some hare populations of moderate to low density, e.g. some Catskill populations in laurel-rhododendron, pitch pine-blueberry and balsam fir types may not be "ailing". Such low population levels may simply represent low but stable population densities that are normal for the type.

The apparent fragility of central and western New York hare populations (excluding the Catskill populations for the purpose of this discussion) poses some fundamental questions: Is it worthwhile to expend human and economic resources in prolonging the survival of hare populations that may, at best, achieve marginal huntability? Or, is an occasional glimpse of a snowshoe hare in the "banana belt" worthwhile? Is the man-aided survival of these hare populations worthwhile when the continued maintenance of other wildlife species on the fringes of their range (e.g. the bobwhite quail in the north) has been routinely abandoned? In terms of hunting benefits alone, the answers to these questions may be negative.

The latter questions can be addressed in a broader context. Since hares are a by-product of conifer stand management in central and western New York, one can ask, of what overall value is the continued presence of such conifer stands and why manage for them? Obviously, they do provide wood products, but so do hardwood stands. They do provide aesthetic diversity, and that may be their biggest asset. According to Bailey and Alexander (1960): "Coniferous cover is a valuable component of good wildlife habitat. A great variety of wild animals find some of their requirements in conifer plantations". Conifer plantations provide important cover for a variety of warblers as well as grouse, rabbits, deer and other species (Bailey and Alexander 1960). More recently, Bortner and Bennett (1980) found that turkeys used a dense conifer stand during cold weather. Apparently, turkeys use conifer stands of younger age classes as escape cover and older trees for roosting, especially when conifer stands are located close to active agricultural land (Porter, 1982, pers. comm.).

In recent years, the number of publics expressing an interest in wildlife conservation issues has increased markedly beyond the former single interest of game production expressed by sportsmen. This is an intensifying trend. Sauer and Barnhart (1983) called attention to the current comprehensive mission and broad scope of activities of the NYSDEC Division of Fish and Wildlife. In a draft of a broad range of fish and wildlife issues identified in New York State, plantations supporting varying hares was listed (Fried 1981). In short, it is probable that decisions on management of the snowshoe hare resource in central and western New York will be made in a broad context.

If hares are to survive in central and western New York, regulations per se will be of little consequence unless a program of hare habitat management is implemented. Again, hare habitat management is of limited value unless it contributes to a comprehensive hare management program in which regulations,

habitat management on public lands, habitat management on private lands, stocking by trap and transfer and education are all important components. As a point of departure, the following components are listed as integral segments of a comprehensive hare management plan for New York State:

1. A formal decision by N.Y.S.D.E.C. to commit a fraction (e.g. 70 percent) of conifer stands on appropriate state lands to replanting with conifers (except larch). Such a decision, possibly expressed as policy, would insure continuity of present conifer stands, especially in central and western New York (Regions 4, 7, 3 and 9).
2. Sites for potential management of snowshoe hares, particularly in central and western New York, carefully selected by DEC wildlife managers and foresters. The nuclear area of such sites would include adequately large tracts of conifer which can be replanted in segments so as to provide a mosaic of age classes in connected and continuous blocks. Conifer stands with existing hare populations are preferable. Where such select areas are adjacent to the lowland mixed softwood-hardwood successional types with *Viburnum* understory, their effectiveness will be markedly increased.
3. Establishment of long-term wood harvesting and replanting schedules for the selected sites, where forest manipulation is practiced on a continuous basis. Harvesting can be commercial, as appropriate, for firewood, pulpwood and dimension lumber. Sources of traditional labor for planting can be augmented by the volunteer labor of hunting clubs and conservation groups (see below).
4. Clear identification of selected forest complexes as special management areas where attainment of ecological diversity, wildlife diversity, management for wood products, management for certain game species (including snowshoe hares) and utilization of these areas as public

demonstration sites, are specifically identified objectives. It is most important that management of these areas is jointly administered by Bureau of Wildlife and Bureau of Forest Resources personnel (or personnel of other appropriate units within the Division of Fish and Wildlife and Division of Lands and Forests). An annually updated management plan (including harvest and planting schedules, and public use) for each area, jointly developed by wildlife managers, foresters and selected public participants will assure continuity of management (such integrated plans are currently being used for Unique Areas under the State Nature and Historic Preserve Trust and its D.E.C. Advisory Council).

5. Involvement of local hunting clubs and conservation clubs in the management activities of selected sites. Responsibility would be placed on hunting clubs and conservation groups (such as the Audubon Clubs) to provide supplemental labor in planting, cutting, making of signs, etc. Jurisdiction of each group would be identified so that there are no conflicts. In return for labor, clubs would participate in appropriate management decisions, censusing of wildlife, and hands-on projects involving wildlife including snowshoe hare trap-and-transfer (see next item) and mist netting of birds, etc. One or more identified club or clubs would "adopt" each special management area and be publicly credited for their contributions.
6. The trap and transfer of snowshoe hares under permit, conducted exclusively by hunt clubs "adopting" special management areas. In my opinion, it would be best to discontinue present stocking by permit of hares purchased from out-of-state sources. However, it would be best to discontinue the current stocking program by hunters only if and when a substitute program (such as the one outlined above) is implemented.

The hands-on activity of trapping and transferring hares would serve as a reward for labor and involvement of private citizens in the special management areas, and add distinction to the club permitted to do the stocking. The latter may stimulate widening participation.

7. An educational program and workshops promoting management of forest wildlife, including snowshoe hares. Management for forest wildlife can be effectively integrated with commercial forest management for wood products on both state and private lands. However, the techniques must be reduced to integrated and simple guidelines that can be practically applied. Such information can be disseminated to extension agents, wildlife managers, foresters, land managers, hunters and other private citizens through various types of workshops. Such workshops conducted for DEC wildlife managers and foresters have been successful. It seems important to continue workshops annually or periodically to reinforce previous experience and to continue dialogue.
8. Modifications of current New York State regulations affecting snowshoe hare hunting and handling, as listed in the 1982-83 New York State Fishing, Small Game Hunting, Trapping, Regulations Guide (p. 72), as follows:
 1. Retain the current open season of October 1 to March 13, and the daily bag limit of 6 hares in northern New York, with boundaries as defined in the guide.
 2. Establish an open season on hare hunting from December 15 to February 28 in the rest of New York State north of Long Island, with a bag limit of 2 hares.
 3. Insert (approximately) the following paragraph on the page of the hunting guide displaying seasons and bag limits:

" Snowshoe hares can easily be hunted out in small patches of cover and conifer plantations. Hares can be exterminated in

such places, even if regulations are strictly followed. Only you can conserve these small populations. Stop all hare hunting when the number of snow tracks is reduced to approximately one half of the early winter level, or when few tracks are visible. Be responsible, and come back to hunt another year!"

The importance of this paragraph can be explained at an annual meeting of the Conservation Council (and other appropriate occasions), and the message disseminated to local federations and clubs. Additionally, an article in the Conservationist about individual responsibility in hare hunting would be effective.

LITERATURE CITED

- Adamcik, R. S., A. W. Todd, L. B. Keith. 1979. Demographic and dietary responses of red-tailed hawks during a snowshoe hare fluctuation. *Canad. Field Naturalist* 93: 16-27.
- Adams, C. C., G. P. Burns, T. L. Hankinson, B. Moore, and N. Taylor. 1920. Plants and animals of Mount Marcy, New York. *Ecology* Vol. 1 (2): 71-283.
- Bailey, J. A. and M. M. Alexander. 1960. Use of conifer plantations by wildlife. *N.Y. Fish and Game J.* 7(2): 130-143.
- Behrend, D. F. 1960. A contribution to the ecology and management of the snowshoe hare in Connecticut. M.S. Thesis, Univ. Conn., Storrs. 55 pp.
- Bortner, J. B., J. W. Bennett. 1930. Observations of wild turkey winter range at Snake Mountain, Vermont. *Trans. 37th Northeast Fish and Wildlife Conf., Ellenville, N.Y.* 243-248.
- Boyle, J. D. 1955. An evaluation of stocking New Brunswick hare Lepus americanus in Massachusetts mixed forest habitat. M.S. thesis, Univ. Mass., Amherst. 67 pp.
- Brocke, R. H. and J. P. Zarnetske. 1974. Resources of the Tug Hill region, wild animals and fish. S.U.N.Y. Coll. Envir. Science and Forestry, Syracuse, N.Y. 157-232.
- Brocke, R. H. 1975. Preliminary guidelines for managing snowshoe hare habitat in the Adirondacks. *Trans. 32nd Northeast Fish and Wildl. Conf., New Haven, Conn.* p. 42-66. (copy in Appendix 2).
- Brocke, R. H. 1977. Mechanics of replenishment of a heavily hunted population of snowshoe hares. Final Report, W-105-R, Study IX, Jobs 1, 2 and 3. 44 pp. (Copy in Appendix 3).
- Brocke, R. H. 1930. Observing snowshoe hares in Adirondack forest openings and management implications. Final Report (in part) for W-105-R, Study X, Jobs 1, 2, 3 and 4. 62 pp. (Copy in Appendix 4).
- Bump, G. 1941. The introduction and transplantation of game birds and animals into the State of New York. *Trans. N. Am. Wildl. Conf.* 5: 409-420.
- Chase, G. T. 1961. A holding pen for varying hares. *N.Y. Fish and Game J.* 8 (2): 150-151.
- Decker, D. J. and T. L. Brown. 1979. Hunting in New York: participation, demand and land access. *N.Y. Fish and Game J.* 26 (2): 101-131.
- Dell, J. 1951. Possibilities of reestablishing the varying hare in certain parts of New York State. N.Y. Fed. Aid in Fish and Wildlife Restoration Proj. W-22-R. N.Y. State Dept. Envir. Cons. (mimeo).
- Dell, J. 1952. N.Y.S. Dept. of Envir. Conservation File, memo.

- Dell, J. 1954. Periodic census of areas at which liberations have been made to determine degree of survival. Fed. Aid in Fish and Wildl. Restoration, Proj. W-22-R-9, Job IIA. N.Y. State Dept. Envir. Cons. (mimeo).
- Dell, J. 1966. Memo to D. Shierbaum on releases of hares by permit. 1 p. D.E.C. file.
- Dell, J. 1976. Summary of comments at Fulton Co. Sportsmen's meeting, Pine Tree Rifle Club, Johnstown, N.Y. 2 pp. mimeo.
- Dept. of Environmental Conservation, 1981. File of snowshoe hare and cottontail rabbit. Federal Aid Reports and Departmental Memos, provided by B. Tullar.
- Fitzpatrick, W. A. 1957. The survival and movements of live trapped and introduced hares (Lepus americanus Erxleben) in Massachusetts. M.S. thesis, Univ. Mass., Amherst. 60 pp.
- Fried, E. 1981. Fish and Wildlife Issues. Part One: Ecosystems and Habitats. Draft Report, NYSDEC, Div. of Fish and Wildl. 75 pp. mimeo.
- Keith, L. B. and L. A. Windberg. 1978. A demographic analysis of the snowshoe hare cycle. Wildl. Monogr. 58, 70 pp.
- Marsters, A. D. 1978. Some characteristics of New York hunters. N.Y. Fish and Game J. 25 (1): 72-78.
- National Analysts. 1975. National survey of hunting, fishing and wildlife-associated recreation. 120 pp.
- Orr, C. D. 1982. Snowshoe hare habitat preferences in Nova Scotia spruce-fir forests. Wildl. Soc. Bull. 10(2): 147-150.
- Porter, W. 1982. Asst. Prof., SUNY College of Environmental Science and Forestry, personal communication on turkey ecology.
- Powell, R. A. 1978. A comparison of fisher and weasel hunting behavior. Carnivore I (1): 28-34.
- Richmond, M. E. and C. Chien. 1976. Status of the snowshoe hare on the Connecticut Hill Wildlife Management Area. N.Y. Fish and Game J. 23(1): 1-12.
- Sauer, P. and G. Barnhart. 1933. A comprehensive wildlife program benefits everyone. The Conservationist 37(4): 14 and 15.
- Schierbaum, D. L. and P. U. Alkon. 1963. Characteristics of a sample of cottontail rabbit hunters in eastern New York. N.Y. Fish and Game J. 10(2): 125-138.

Schultz, W. C. 1978. Acclimation of stocked New Brunswick hare (Lepus americanus) in Massachusetts. M.S. Thesis, Univ. of Mass., Amherst, 65 pp.

United States Dept. of Interior. 1972. National survey of hunting and fishing. Bur. Sport Fisheries and Wildlife, Wash., D.C.

Wolfe, M. L., N. V. Debyle, C. S. Winchell, and T. R. McCabe. 1982. Snowshoe hare cover relationships in northern Utah. J. Wildl. Manage. 46 (3): 662-670.

Wolff, J. 1980. The role of habitat patchiness in the population dynamics of snowshoe hares. Ecol. Monogr. 50(1): 111-130.